List of Appendices

APPENDIX A: Agenda

Agenda

Long Term Monitoring Sensors/Analytical Methods Workshop

WEDNESDAY, June 13

Users Perspective

1:30 pm Tom Schneider, Office of Federal Facilities Oversight, Ohio EPA
Stewardship and Technology: Challenges of the Future

1:45 pm Bob Wood, RPM for Edwards AFB, Chief of the Environmental Restoration Division
Use of Sensors to Support Long-Term Monitoring & Long-Term Operations at Edwards AFB, CA

2:00 pm Kathy Yager, EPA Technology Innovation Office
Industry/Responsible Party Receptiveness to the Use of Sensors for Long-Term Subsurface Monitoring

Perspective from Researchers Who Have Worked on Monitoring Technologies in the Field

2:15 pm Joe Rossabi, Principal Engineer, SRS, and Roger Jenkins, Group Leader, ORNL
True Grit - True costs, true needs and other realities of Long-Term Monitoring

Overview of Workshop and `Ground Rules' for Meeting

2:45 pm Caroline Purdy, Concurrent Technologies Corporation
Purpose, Objectives and Expectations from Workshop

3:00 pm Break

APPENDIX A: Agenda

#1 Breakout Sessions – Functional Requirements

3:30 – 5:30 pm VOCs/Semi-VOCs in Groundwater
Moderator Rodger Jenkins (with Joe Rossabi)

VOCs/Semi-VOCs in Soils and Vapor
Moderator Carol Eddy-Dilek (with Bryan Looney)

Metals in Soils and Groundwater
Moderator Bruce Friedrich (with Glenn Bastiaans)

Radionuclides in Groundwater and Soils
Moderator Bill Haas

Topics to be Discussed

Needs identified:
Two documents will be prepared and made available to all participants to keep this discussion short
- Consolidated needs table
- Summary of primary contaminants in plumes at each major site

Functional requirements for LTM sensors/analytical methods:
Engage the users in these possible discussions
- What will emerge as standard monitoring systems in the future including:
  - Deployment of sensors
  - Deployment of sampling equipment
  - Retrieving samples
  - Retrieving sensors
- Use of existing wells? Or flexible sampling locations?
- Automation or technician involvement
- Acceptability from regulators
- Data retrieval
- Cost limitations

APPENDIX A: Agenda

THURSDAY, June 14

8:00 am	VOCs/Semi-VOCs in Groundwater Representative
8:15 am	VOCs/Semi-VOCs in Soils and Vapor Representative
8:30 am	Metals in Soils and Groundwater Representative
8:45 am	Radionuclides in Groundwater and Soils Representative
9:00 am	Open Forum: Questions, Discussions and Comments from All Participants on Session #1 Conclusions
9:30 am	Donna Hale, INEEL *Overview of EMSP Sensor Research*
9:45 am	Break
	#2 Breakout Sessions – Path Forward
10:15 am	VOCs/Semi-VOCs in Soils and Vapor Moderator Joe Rossabi (with Roger)
	VOCs/Semi-VOCs in Groundwater Representative Moderator Carol Eddy-Dilek
	Metals in Soils and Groundwater Moderator Glenn Bastiaans (with Bruce)
	Radionuclides in Groundwater and Soils Moderator Bill Haas

Topics to be Discussed

Identify available technologies, evaluate what techniques meet the requirements
- What sampling techniques and deployment platforms will meet the requirements?
- What sensing methods (available and/or emerging today) are best suited for the requirements?

What should the future R&D program include?
- What are the shortcomings for the current technologies?
- How can we improve on existing methods?
- What methods and/or strategies should future systems include?
- What level of development is needed?
- What technologies might require short term R&D for quick turnaround applications?
- What should be the R&D focus in near-, intermediate-, and far-term?

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FRIDAY, June 15

8:00 am	VOCs/Semi-VOCs in Groundwater Representative
8:15 am	VOCs/Semi-VOCs in Soils and Vapor Representative
8:30 am	Metals in Soils and Groundwater Representative
8:45 am	Radionuclides in Groundwater and Soils Representative
9:00 – 11:30 am	Open Forum: Questions, Discussions and Comments from All Participants on Session #2 and Summary of Conclusions

Workshop Objectives

- Assess current LTM chemical sensor & analytical needs
- Define the technical functional requirements for those needs
- Evaluate current technologies against functional requirements
- Assess technology shortcomings and gaps
- Identify LTM strategies
- Identify LTM R&D for chemical sensors

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Long Term Monitoring Sensor/Analytical Methods Workshop
June 13-15, 2001
Final Registration List

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DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
VOCs

2. What was/were the most valuable ideas that came out of the workshop?
That sensors for vocs have been developed and some are available for evaluation or use.

3. What was/were the most important recommendation that came out of the workshop?
The recommendation to utilize "on/off" switch as part of a sensor system, to notify responsible person(s) of an excursion from a baseline, based on a predetermined trigger level.

4. What did you like best about the workshop?
The gathering together of professionals who have similar challenges, working together to attempt to solve the problems.

5. What did you like least about the workshop?
A rather slow start in discussing the specific objectives and challenges, and identifying potential solutions or paths forward. There was a bit of confusion regarding what constitutes a "user" vs. a "supporter" and this caused a bit of a delay. The facilitators were good, but failed to always keep discussions on the specific objectives.

6. Did you think we accomplished the objectives set out for the workshop?
I believe so, but I missed Friday AM session and don't know what was ultimately presented in summary/conclusion.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
7

Please provide any comments that will help us improve on the next workshop!

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
I attended the Rad breakout sessions.

2. What was/were the most valuable ideas that came out of the workshop?
People are starting to focus on what their "true" needs are and I think with a bit of time in between the workshops/meetings everyone will have time to check with the (necessary) users at the individual sites, as well as further investigate some of the technologies that are being developed or are already commercial. This is forcing everyone to seriously look at the planning and issues of LTS.

3. What was/were the most important recommendation that came out of the workshop?
Probably that there is definitely a need to find/further research and develop sensors for long term, in situ use (i.e., it is a very urgent need at most or all of the DOE sites that must be funded in the near term in order to be tested and ready for site closures and stewardship).

4. What did you like best about the workshop?
Getting people from industry, the different sites, regulators, and other entities talking together to try to figure out the path forward was a great start. Sometimes the sites forget that there are numerous others dealing with the same issues, and putting the heads together does help.

5. What did you like least about the workshop?
I think, in some cases, there were individuals that were developers and/or DOE site contractors that were not users and were not totally aware of the users real needs, but that spoke for the sites as if they were the user. It was frustrating to hear the needs of a particular site that we have been working with being presented as very different than what we have been hearing from the (real) users. I also think maybe starting out with a smaller focus would help. I know that it didn't sound like a major problem on paper, but so many issues seem to need to be discussed before the functional requirements can be set for the different contaminants.

6. Did you think we accomplished the objectives set out for the workshop?
I was not there for the Friday morning session, but as of the end of the Thursday afternoon session I did not feel that our group really came up with a set of functional requirements for the rad sensors.

I think that the information that was handed out is very helpful and that once people have a chance to review all of it, they will be attending the future workshops/meetings with a lot more knowledge and possibly a better focus.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes, but maybe it would be more clear to have each of the researchers have 10 minutes to present their sensor research so that everyone had the knowledge of what is out there now for their particular contaminants of concern.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
9 -- The facilitators did a good job at trying to keep the focus of the group -- they had to keep pulling some people back to the issues at hand. They also helped summarize and pull together some of the (random) thoughts that were mentioned.

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
Radionuclide Sensors

2. What was/were the most valuable ideas that came out of the workshop?
I found it interesting to note that so many people thought moisture sensors were some of the most important applications.

3. What was/were the most important recommendation that came out of the workshop?
Wasn't there for the end so didn't see recommendations

4. What did you like best about the workshop?
Seeing that DOE is working to develop this technology for application to LTM and that many folks have the same concerns/problems.

5. What did you like least about the workshop?

6. Did you think we accomplished the objectives set out for the workshop?

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
7

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC's
Developer

2. What was/were the most valuable ideas that came out of the workshop?
I got a better understanding of the types of monitoring i.e. long-term, processing etc
also ~~overall~~ how hard to go from development to deployment

3. What was/were the most important recommendation that came out of the workshop?
To get the developers to work with end users doing the development to get preliminary testing with real samples & possibly on-site before full validation

4. What did you like best about the workshop?
The interactions between developers & user

5. What did you like least about the workshop?
Would like to have more representation by industry

5. Did you think we accomplished the objectives set out for the workshop?

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective). 8

Please provide any comments that will help us improve on the next workshop!
Would like to see one on process monitoring or when there is more change happen at site prior to the long-term monitoring.

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
Organics in Water and Air

2. What was/were the most valuable ideas that came out of the workshop?
The group began to understand that the development and deployment of sensors for environmental and process optimization will need a systems acquisition approach. The actual end user requirments, the varying conditions, the operator capabilities, the software, and communications support, all need to be considered for the system to function.

3. What was/were the most important recommendation that came out of the workshop?
The problem can benefit from gathering real world experience with the sensors that are ready to deploy in field tests. The way that this information and lessons learned will be captured and shared with the rest of the R&D community was not discussed aqnd is not clear to me. Some organization needs to take up the challenge to create a sensor newsletter/web page to foster open communication of successes and failures.

4. What did you like best about the workshop?
The interaction of the R&D developers, the users, and private sector entrepreneurs; all bringing unique perspectives to the floor for discussion.

5. What did you like least about the workshop?
Limited time. This meeting could have been more productive if it ran for 3 1/2 days. A clearer agenda and objectives could have been mailed to the participants well in advance of the workshop, with some read ahead papers and questions each participant should be able to discuss at the meeting.

6. Did you think we accomplished the objectives set out for the workshop?
Yes, the challenge has been presented, and I think the sensor community understands the task. Unfortunately the senior leadership of DOE, EPA, DOD and DOI who must prioritize the R&D efforts, have a great deal to do with focusing the R&D funding, and ultimately develop agency policy and promulgate regulations were not present. If senior agency officials, (just one will do, but two are better) sign up to the objective of having a functional sensor deployed within accepted regulatory guidance in 3 years the program will succeed. Without this top down support the prospect of getting the program acepted from the grass roots up is unlikely. We need one success. Edwards AFB may be that success, but changing government views is well beyond our capability.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes, but better pre-meeting guidance and marketing would have been beneficial by having all of the attendees better prepared.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
Very capable, they had the experience and leadership skills to keep the group focused. I give them a 10.

Please provide any comments that will help us improve on the next workshop!

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
Metals in Soil and Groundwater

Per your request at the conference to identify ourself, my name is John Kubarewicz from Oak Ridge and a user.

2. What was/were the most valuable ideas that came out of the workshop?
From my (user) perspective I felt it was to focus on surface water sensors rather than groundwater as that is the larger cost driver and to use surrogates in the vadoze zone such as water level, pH, conductivity vis specific chemicals/metals/rads.

3. What was/were the most important recommendation that came out of the workshop?
My favorite was to focus next on applied development and to team the developer(scientist) with someone experienced in developing the systems (engineer?) and a user. As development progresses from applied research to demonstration then deployment the different team members would have expanding or declining roles depending on the need at that phase.

4. What did you like best about the workshop?
Interaction between users and developers, involvement of multiple agencies and industry. I got to share (and am continuing to do so) lessons learned with a Dupont person that is looking into solving similar problems.

5. What did you like least about the workshop?
I think it was a great opportunity to get a lot of good input, but we were limited in defining needs and solutions by those that attended and how they spilt up into sessions. I am concerned that we still need to check on other solutions and update needs from a broader group. For example Oak Ridge was not representated at the radionuclides session and consequently was not recognized in their summary as having a need and had no input (we have a large uranium monitoring need). Maybe CMST can do that based on last year's SCFA/CMST Site visits with a few follow-up calls and a technology search? Paul seems to have a good understanding of the issues/available solutions.

I was also a little concerned that the developers greatly outnumbered the users and that any summary and follow-up would focus on developers input only. I got most concerned when one of the developers said that "the users had their input and now it was time for them to get out of the way!" I'd like to stay involved to provide updated user input and suggest that we get other "volunteers" to do the same.

6. Did you think we accomplished the objectives set out for the workshop?
Within the constraints set by the attenedees/session spilt (see #5), I think we did. Just need to get the other information I mentioned to be inclusive and represent all needs/technology.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes, I liked the format much better than one large workshop.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
I would give them an 8. It was a small group with some more vocal sorts so it was difficult to get everyone going, but they did quite well and I believe that everyone got to speak.

Please provide any comments that will help us improve on the next workshop!

Appendix D: Evaluation Sheets

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
VOC's

2. What was/were the most valuable ideas that came out of the workshop?
A few come to mind in my opinion, first the end users perspective that everything should be presented in a basic military manner, not requiring the highly skilled scientist to operate the equipment/sensor/monitor. The end-user don't want a spectroscopist needed at the site, this is one of the main impediments to the new technology. The end users felt if a sensor could last for even three years without constant maintenance it would be successful. Another valuable idea came about in the form of the perceived needs from the sites, there is a need for these "super-sensors", and there is a huge gap between what is now being developed or already developed versus what the end-users would like. The challenge will be for PI's to miniaturize the sensors, make them rugged, and dependable in the years to come.., I think the performance that the users what is a big gap compared with what OST currently has in its portfolio.

3. What was/were the most important recommendation that came out of the workshop?
I didn't see recommendations in the session I attended. I thought the researchers were of course interested in the possibilities of more funding, not necessarily the agenda of what CMST/SCFA plans to accomplish in this workshope

4. What did you like best about the workshop?
The passionate discusssion of what was needed in this science arena.

5. What did you like least about the workshop?
I think the next time CMST has to look very closely at what the specific requirements they are trying to achieve, and match that up with the specific task of the working groups. The VOC group continually kept going off on these tangents, and only wanted to discuss the science. I also felt it was wrong to assume the "end-users" requirments were what we, CMST say they are, they are wrong because not all of the end users had representation at the workshop; for us to assume this is the requirements without there buy in, it would be similar to what ID did last year, and rubbed several organizations wrong in the process. I lastly thought CMST was given second class status in the workshop even though we were given all the task to make it happen; SCFA was given all the credit and this was flat out wrong.

6. Did you think we accomplished the objectives set out for the workshop?
partially, CMST was relying on the end users substantially to get there input as too if the sensors now in existence can meet their needs, and I feel this was not accomplished; this was totally out of our control as well.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes. But CMST needs to look at new ways to get the PI's to understand the end users perspective, I felt they were on deaf eyes with the PI's.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
VOCs

2. What was/were the most valuable ideas that came out of the workshop?
Standardizing of various stages of development. The idea that these sensors don't need to be commercial, we can build them as we need them. It was promising to the see that sensors are being developed and are available for testing.

3. What was/were the most important recommendation that came out of the workshop?
Standardizing on the definition of long term monitoring. Each end user seemed to have their own interpretation.

4. What did you like best about the workshop?
The discussions with the developers and their technology.

5. What did you like least about the workshop?
The review of the published need. This was a big waste of effort.

6. Did you think we accomplished the objectives set out for the workshop?
To some extent.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes. However, not all ideas were given the amount of time needed for discussion.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
5, Sometimes they seemed to have their own agenda, especially during the review of the needs.

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? RADS / DEVELOPER

2. What was/were the most valuable ideas that came out of the workshop?

users & developers need to communicate

3. What was/were the most important recommendation that came out of the workshop?

There are some technologies available to meet the user's needs but have been neglected due to loss of funding.

4. What did you like best about the workshop?

Informal setting with time available for open exchange of ideas

5. What did you like least about the workshop?

5. Did you think we accomplished the objectives set out for the workshop?

Yes, for the attendees present. Not all sites (users) were represented and there are technologies being developed that were not discussed due to insufficient background.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?

yes.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

Good - Sometimes difficult to stay on track due to specific interests of attendees. Facilitators did a good job keeping to the objectives of workshop

Please provide any comments that will help us improve on the next workshop!

As a researcher, I was frustrated by the disconnect between funding development of technology that appears to be needed and satisfy the user. I was also made aware that there are potential funding opportunities that we (developers) are not being made aware. Where is the disconnect? (OVER)

We need more ~~technology~~ meetings of this type where the users are
given opportunity to express ~~theirs~~ their needs directly to the
technology developers. The DOE Needs statements are
very generic and are almost unattainable. We need to
discuss the real requirements in detail and compromise
on some reasonable (and possibly achievable) requirements.

Where do we go from here? How can workshops of
this type influence funding agencies and commercial
developers? This is the right mix of users/developers to make
progress on LTM. Most of time, this combination is ~~not~~ rarely
available. This type of discussion & interchange should be the bases for future development.

Ken Hofstetter
SRTC

DOE Sensor Workshop Evaluation/Comment Sheet - USER

1. Which Breakout Session did you primarily attend? RADs

2. What was/were the most valuable ideas that came out of the workshop?
   - Moisture monitoring is very important.
   - We aren't there yet for cost effective LTM.

3. What was/were the most important recommendation that came out of the workshop?
   Need for commercial rad monitors.

4. What did you like best about the workshop?
   Very good turnout and discussions

5. What did you like least about the workshop?
   Not all sites sent people. This is a critical issue for all sites.

5. Did you think we accomplished the objectives set out for the workshop?
   Yes

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   Yes

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   8

Please provide any comments that will help us improve on the next workshop!

You need to find a way to get more endusers to these workshops and to get workshop information to.
Please get this information into the DOE. Cover and Monitoring Guidance Document that is supposed to [illegible]

Metals group

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? technology facilitator and developer

2. What was/were the most valuable ideas that came out of the workshop?
   - We may not need remote automated sampling everywhere
   - We could collect too much data (can't manage/digest all of it properly, public access to raw data could be problematic if they don't understand the nature of sampling data, false positives)
3. What was/were the most important recommendation that came out of the workshop?
   - Consider using suregate sampling (pH, Eh, temp, moisture etc.) for indication of change or performance instead of multiple specific metals.
   - We need to keep the development pipeline full, currently we are weak in gates 3-5
   - We need more lead time on proposals
   - Potential usefulness of integrated samples
4. What did you like best about the workshop?
   Small discussion groups to hear from multiple Labs and backgrounds.
   I think the duration was about right.
   Nice combination of break out + plenary sessions.

5. What did you like least about the workshop?
   I think we needed more users and we needed more participation from USGS, EPA, DoD + industry (both for users + developers)

5. Did you think we accomplished the objectives set out for the workshop?
   I think so, but I worry that we may not really understand/decided all the types of data that will be needs for longterm stewardship. I would suggest:
   1. compliance 2. liability 3. performance 4. prediction/modeling
   I'm not sure we had the right people to identify the low hanging fruit.
6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   yes, but I'm not sure we did the best job of thinking outside of the box

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   9, having 2 people working together to lead, plus a note taker was a good approach

Please provide any comments that will help us improve on the next workshop!

I would consider having an invitation only format to get the right mix of participants and to ensure full term participation. ~~Maybe~~ Also pull more folks from EPA, state regulators, industry, DoD, USGS. Might get some folks from ITRC. I am working in the Long Term Stewardship national program and I would like to know about future workshops. Gretchen Matthern 208-526-8797 gtn@inel.gov

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC ground | vapor

2. What was/were the most valuable ideas that came out of the workshop?

   Current Sensor Development trends

3. What was/were the most important recommendation that came out of the workshop?

   adopting COTS technology. For MEMS Single sensor 450K - Single sensor proof of concept for Concept TO manufacturing 2.5-3 million per sensor type

4. What did you like best about the workshop?

   interface between "users" & "developers"
   The workshop was well thought out. - good organization

5. What did you like least about the workshop?

   ~~[illegible]~~
   Too short

5. Did you think we accomplished the objectives set out for the workshop?

   yes

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?

   yes

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

   8

Please provide any comments that will help us improve on the next workshop!

DOE Sensor Workshop Evaluation/Comment Sheet john.gladden@srs.gov

1. Which Breakout Session did you primarily attend? metals

2. What was/were the most valuable ideas that came out of the workshop?
   - Serious concerns about cost:benefit which generally led to "is real time monitoring worth the anticipated cost".
   - Is RTM needed for LTM?
   - Need for reexamination of funding + proposal mechanisms

3. What was/were the most important recommendation that came out of the workshop?
   - Consensus on need for surrogate measures for "system performance"
   - Importance of incorporating flux into program (GW or SW?)

4. What did you like best about the workshop?
   - Numerous issues that may, or may not, have directly addressed the a priori objectives of the workshop arose in discussions. (e.g. surrogate measures, flux + hydrology)
   - Direct interaction of developers + users helpful to both

5. What did you like least about the workshop?
   Inadequate a priori definition of requirements/objectives of LTM.

5. Did you think we accomplished the objectives set out for the workshop?
   No. Still not convinced that we all fully understood the objectives + desired outcome.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   Yes.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   8

Please provide any comments that will help us improve on the next workshop!
- Need to better define the objectives and requirements of LTM to establish boundary conditions for discussion.
- Issues that were not addressed were data management + presentation which will be key if RTM is really needed.
- Need for integrating sensors/approaches that provide information integrated over space or time - can include biological "sensors"

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? Metals - as a developer

2. What was/were the most valuable ideas that came out of the workshop?
   - That the "needs" statements may be more of a "wish list" than something that is practical to reach within ~3 years

3. What was/were the most important recommendation that came out of the workshop?
   In situ monitoring does not need to provide continuous data - in fact the users don't want it

4. What did you like best about the workshop? - Being able to talk directly to the users of the technology

5. What did you like least about the workshop? - Too many DOE people - not enough people or ideas from outside the DOE Complex

5. Did you think we accomplished the objectives set out for the workshop?

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   I went to 2 groups and this format was very dependent upon the facilitators - the Rad people did a much better job than the metals

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   Our moderators had pretty fixed ideas about what they thought was important in a sensor - and that dominated the discussions.

Please provide any comments that will help us improve on the next workshop!
It would really help those non-DOE people if the moderators identified speakers by their first and last names.

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC (Developer)

2. What was/were the most valuable ideas that came out of the workshop?

1. Need for standardization
2. For me, the realization that there seems to be impediment to simple solutions (i.e. developer doesn't make money!)

3. What was/were the most important recommendation that came out of the workshop?

1. Need better understanding of real site needs (not the generic needs statement)
2. Need for a standard "backbone" for people to build for.

4. What did you like best about the workshop?

(1) Chance to hear from real users
(2) Chance to talk to current field experts

5. What did you like least about the workshop?

Too many developers trying to sell specific sensor ideas rather than focusing on what is really needed and realistic.

5. Did you think we accomplished the objectives set out for the workshop?

We saw a few potentially useful sensor ideas. However, we need to spend more time determining what measurement is really needed rather than discussing sensors.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?

Yes, but needed more users

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

8 - Did an excellent job and tried to keep to workshop goals

Please provide any comments that will help us improve on the next workshop!

Participants here didn't seem to understand "Long Term". Much of the discussion focused on current SCFA needs, which are valid. However the "long term" component was lost. What do we really need quantitatively + qualitatively

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC/SVOC

2. What was/were the most valuable ideas that came out of the workshop?
Funding, commercialization issues

3. What was/were the most important recommendation that came out of the workshop?

4. What did you like best about the workshop?
Good opportunity to delve into the sensor state of the art and look for integration, adaptation to specific needs

5. What did you like least about the workshop?
Users, developers, and supporters did not seem to have a common understanding of LTM/Stewardship needs. There were very diverse objectives and a lack of consistent end state condition

5. Did you think we accomplished the objectives set out for the workshop?
Workshop did a good job of discussing sensor technology and functional requirements for sensors. The workshop did not do a good job of clearly defining LTM strategies and requirements which will further influence sensor needs and functional requirements

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes. Future workshops may benefit from better defined user needs

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
Good, perhaps a little too involved and focused on specific aspects of the technologies

Please provide any comments that will help us improve on the next workshop!
Provide better overview of LTM/Stewardship Program and strategic needs to provide context for technology needs and commercial potential. Developers may benefit from a better understanding of the scope and scale of LTM/Stewardship at DOE/DOD and EPA private sector sites.

DOE Sensor Workshop Evaluation/Comment Sheet

Evan Dresel

1. Which Breakout Session did you primarily attend? Radionuclides / primarily User

2. What was/were the most valuable ideas that came out of the workshop?
I'm excited about the application of VOA sensors.

3. What was/were the most important recommendation that came out of the workshop?
Development of many systems won't occur in private sector
DOE must invest in this + in bridging gap to field application

4. What did you like best about the workshop?
Understanding of similarities & differences around complex

5. What did you like least about the workshop?
Didn't hear enough from developers.
Don't have a good idea of what is in pipeline + stage of development.

5. Did you think we accomplished the objectives set out for the workshop?
Not quite – but a start

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Rad. group didn't get enough input from researchers,
Spent too much time on requirements (not focused enough)

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

5

Please provide any comments that will help us improve on the next workshop!
I felt that the rad group spent too much time on issues which, even if important, were not getting us very far.
Need to hear More from DOE on funding/research/political issues.

DOE Sensor Workshop Evaluation/Comment Sheet CMST - GJB

1. Which Breakout Session did you primarily attend? Metals

2. What was/were the most valuable ideas that came out of the workshop?
   Recommendations on path forward

3. What was/were the most important recommendation that came out of the workshop?
   Several rec's were important: start field deployments now; more applied research; use of surrogate indicators

4. What did you like best about the workshop?
   user/~~[illegible]~~ developer interactions

5. What did you like least about the workshop?
   CMST program

5. Did you think we accomplished the objectives set out for the workshop?
   Yes, to a large extent

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   The break out ~~[illegible]~~ sessions were good. Discussion topics can be developed further

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   9 to 10

Please provide any comments that will help us improve on the next workshop!

Build upon lessons learned at this Workshop

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? metals / developer

2. What was/were the most valuable ideas that came out of the workshop?
   that real-time monitoring is not really needed

3. What was/were the most important recommendation that came out of the workshop?
   that there are technologies available
   they just need field experience data

4. What did you like best about the workshop?
   ~~[illegible]~~ the encouragement to ~~[illegible]~~ participation
   by many of the participants - no one
   person dominated the discussions (except maybe VOC's)

5. What did you like least about the workshop?
   the meeting room - should be a little bit wider
   to get more people up closer so you don't
   need a microphone

5. Did you think we accomplished the objectives set out for the workshop?
   we did discuss sensors but I'm not sure
   the development + deployment process will
   change based on this meeting

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   yes

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   9

Please provide any comments that will help us improve on the next workshop!
needed more users in metals and more developers
in rads - though I think you did a good
job getting as many people here as you did

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC & SVOC

2. What was/were the most valuable ideas that came out of the workshop?
DOE HQ must begin to require standardization of equipment used to create a market -

3. What was/were the most important recommendation that came out of the workshop?
don't worry about commercializing - build the sensors w/ DOE resources & use them -

4. What did you like best about the workshop?
Nice setting, opportunity to interact w/ person from other locations about other research topics

5. What did you like least about the workshop?
Topics being discussed did not move things forward by any substantive amount -

5. Did you think we accomplished the objectives set out for the workshop?
Only those that were

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
format maybe -- but the sample topics for discussion were poorly chosen -

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

2

Please provide any comments that will help us improve on the next workshop!
In future efforts try to separate the problems associated w/ sampling & measurement - Sensors deal w/ measurement - don't complicate it -

A lot of discussion centered around issues of interest to individual researchers or pet projects. A quantum change in deployment will not be achieved by this type of conversation. Only generic ~~[illegible]~~ guesses @ performance standards were identified. A golden opportunity existed to focus on performance requirements such as how the individual sensors must interface with a sampling platform, how to demonstrate equivalence to an EPA method, restrictions to access for servicing, etc. Little focus was given to how DOE HQ policies on standardization of equipment itself can create a market.

Statements made in Workshop –

a) "the biggest problem w/ this field is there is no market".

b) DOE represents the largest environmental market in the world –

⇒ establish a linkage – – if you build it, they will come –

ROGER JENKINS

Developer/Facilitator

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOCs/SVOCs

2. What was/were the most valuable ideas that came out of the workshop?
   Update on what new sensor concepts are out there

3. What was/were the most important recommendation that came out of the workshop?
   Formal recommendation that more effort & resources ~~goes~~ into bridging the gap ~~[illegible]~~ to commercialization, & field testing of existing sensors

4. What did you like best about the workshop?
   Degree of interaction among participants

5. What did you like least about the workshop?
   Only a small criticism => would like to have had some time to hear a bit more about what is going on in other sessions.
   Also => would like to have had more "Users" at the meeting, especially those outside DOE system

5. Did you think we accomplished the objectives set out for the workshop?
   Yes

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   Yes => Very much so. Less formal talks and more discussion is more effective

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   9, but then I was a facilitator

Please provide any comments that will help us improve on the next workshop!

I really liked the Wed PM All Day ~~[illegible]~~ Thurs & Fr. morning format.

Developer

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC's, but also other 2 to lesser extent.

2. What was/were the most valuable ideas that came out of the workshop?
Surprising number of viable technologies available for evaluation.

3. What was/were the most important recommendation that came out of the workshop?
Working w/USGS.
Looking @ other agency monitoring practices (take the blinders off)

4. What did you like best about the workshop?
Summaries by the moderators are valuable consolidations of the very diverse material presented and discussed.

5. What did you like least about the workshop?
Difficulty of focus on needs (we did not have a clear consensus on needs). Low $\frac{\text{user}}{\text{developer}}$ ratio.

5. Did you think we accomplished the objectives set out for the workshop?
I think so, but we raised more questions than we answered. The product is the session summaries.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Yes. Breakouts were good. Excellent work on the part of the session moderators to pull it all together.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
10 (especially considering the diversity of the participants)

Please provide any comments that will help us improve on the next workshop!
- Best food of the whole conference...
- Kick off the next one with a ~~sum~~ summary of existing (ie, in catalogues) measurement technologies, and current monitoring approaches.

Bill Lowry blowry@seabase.com

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? RAD (user)

in-situ sensor may not be possible or necessarily - bringing sample to surface may remain the way to go

autosampling becomes important

2. What was/were the most valuable ideas that came out of the workshop?

importance of moisture + moisture flux

is there a market outside of DOE/DOD for rad sensors? probably not

3. What was/were the most important recommendation that came out of the workshop?

* definition of LTM critical to set + meet objectives (i.e., is LTM tens of yrs vs hundreds of yrs)

4. What did you like best about the workshop?

working groups

5. What did you like least about the workshop?

5. Did you think we accomplished the objectives set out for the workshop?

generically, yes
specific functional requirements, not

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?

I believe if the users would have prepared prior to meeting, requirements may have been easier to finalize.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

7

Please provide any comments that will help us improve on the next workshop!

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? metals

2. What was/were the most valuable ideas that came out of the workshop?
   more input from End users

3. What was/were the most important recommendation that came out of the workshop?
   get Engineers/developers to work with the original researchers for finalize/commercialize the new Sensors

4. What did you like best about the workshop?
   The complete open-atmosphere for suggestions/comments

5. What did you like least about the workshop?
   The Lack of (or not enough) Commercial organizations (for final sensor development).
   *. only 2 companies were in the Group.

5. Did you think we accomplished the objectives set out for the workshop?
   Yes.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
   Need more input from users.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   7

Please provide any comments that will help us improve on the next workshop!

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? Radionuclides / Developer

2. What was/were the most valuable ideas that came out of the workshop?
Need for moisture measurements in vadose zone
Need to use/modify existing technology for remote sensing.
Quantification may not be the most important factor for LTM.

3. What was/were the most important recommendation that came out of the workshop?
Develop sensors for tritium, Tc-99.
LTM needs to begin now with existing technology. As new systems become available, deploy and replace old systems. Use existing borehole/well if at all possible.

4. What did you like best about the workshop?
Thrust for vadose zone LTM.

5. What did you like least about the workshop?
Emphasis on CPT to deploy sensors. Serious problems associated with CPT.
Outcomes were obviously pre-determined.
Needs a reality check. It is likely any sensor development will come from in-house sources - not vendors for radionuclides.

5. Did you think we accomplished the objectives set out for the workshop?
Partially. In order to change the DOE/Regulator culture regarding groundwater emphasis over vadose zone will require further workshops primarily with "Users".

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Not enough users present - those that were present did not seem to believe regulators would "buy in" to the vadose zone emphasis. Appeared to be too many "plants" in group.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
Too effective. Dominated ~~their~~ the discussion emphasizing ideas that fit their pre-conceived notions.

Please provide any comments that will help us improve on the next workshop!
Need to have similar forum with Users and Regulators and Stakeholders.

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? metals /VOCs

2. What was/were the most valuable ideas that came out of the workshop?
need for standardization of sensor platforms, interfaces. Suggestion for DOE to manufacture or contract manufacture of selected sensors/monitoring systems, vs. trying to lure vendors into commercialization.

3. What was/were the most important recommendation that came out of the workshop?
See #2.

4. What did you like best about the workshop?
open discussions. well organized. Included some reps "outside" the DOE system, e.g. DoD, USGS, EPA...

5. What did you like least about the workshop? Heavy on tech. developers.
In some cases, functional rqts. did not fully allow for varied application needs, e.g. indicators of incipient failure of engineered containment structures, rather than just regulatory monitoring. Random representation of technologies

5. Did you think we accomplished the objectives set out for the workshop?
Well - technologies and needs were randomly represented. So, results could not be considered accurately representative.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
- Yes, excellent, for a workshop
- To get the full range of user needs and technologies, someone will need to do focused surveys of users and literature searches, surveys, etc. for technologies.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
Excellent

Please provide any comments that will help us improve on the next workshop!
I don't think an additional workshop would be productive. Some one needs to "beat the bushes" to do the homework on needs and technologies. Then CMST + SCFA lead lab should recommend to SCFA management how to proceed.

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? VOC

2. What was/were the most valuable ideas that came out of the workshop?
User needs, however, they were not new ideas.

3. What was/were the most important recommendation that came out of the workshop?
The need to do longer term research + development on sensor.

4. What did you like best about the workshop?
Snacks!! Summary discussions

5. What did you like least about the workshop?
Undirected discussions. The facilitators needed to structure the discussion to a greater extent.

5. Did you think we accomplished the objectives set out for the workshop?
Yes + No. –

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
Users were in short supply. Next time you might want to invite more users to the meeting.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
5

Please provide any comments that will help us improve on the next workshop!
see 6. + 5

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend? Rad user/tech/integrator

2. What was/were the most valuable ideas that came out of the workshop?

   identification of similarity in needs and the strong agreement on underlying parameter information needs (especially water flux)

3. What was/were the most important recommendation that came out of the workshop?

   Recommendation to look at sequence of steps to develop LTM — multiyear focus w/ evolution to timely long term with demonstration of qualitative systems and their value

4. What did you like best about the workshop?

   work groups and exchange of ideas on problems and perception of options

5. What did you like least about the workshop?

   The workshop was light on technologists in the rad area and was therefore very "blue sky" in focus on needs and requirements definition.

5. Did you think we accomplished the objectives set out for the workshop?

   Overall, yes — opportunities are wide open for follow on workshops

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?

   Yes — this group could form the basis for longer term work-groups

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

   8 very good — they could have been helped by true facilitators (eg. Enviro Issues)

Please provide any comments that will help us improve on the next workshop!

It would be valuable to include representatives from other organizations and technical areas that are doing long term monitoring — oceanographers (MBARI & Naval Research have continuous monitors for ODP wells). NEWNET does atmospheric remote monitoring

DOE Sensor Workshop Evaluation/Comment Sheet

CLIFF HO
SNL
DEVELOPER

1. Which Breakout Session did you primarily attend? VOCs IN SOILS/GROUNDWATER

2. What was/were the most valuable ideas that came out of the workshop?
SENSORS DO NOT NECESSARILY NEED TO DETECT MCL. CAN USE SENSORS IN PROCESS APPLICATIONS TO DETECT CHANGES & TRENDS. NEED CALIBRATION METHODS. HARD TO COMMERCIALIZE SENSORS IN ENVIRONMENTAL WORLD.

3. What was/were the most important recommendation that came out of the workshop?
WE NEED MORE APPLIED/DEPLOYMENT ACTIVITIES TO GET THE SENSORS IN THE FIELD.

4. What did you like best about the workshop?
HAVING THE DEVELOPERS STAND & SUMMARIZE THEIR TECHNOLOGIES (GOING THROUGH THE "GAUNTLET"). I THINK THIS WAS EXTREMELY USEFUL FOR BOTH DEVELOPERS & END-USERS. I ENJOYED ~~SEEING THE~~ HAVING THE OPPORTUNITY TO SPEAK WITH END-USERS AND DISCUSS FIELD OPPORTUNITIES.

5. What did you like least about the workshop?
"INTRODUCTORY" TALKS & DISCUSSIONS COULD BE SHORTENED. MANY OF THE "OPEN" DISCUSSIONS ~~WER~~ DURING THE LARGE-GROUP MEETING BECAME SCATTERED AND UNPRODUCTIVE. SOME GOOD IDEAS ~~WERE~~ AND ISSUES WERE ~~BR~~ BROUGHT UP, BUT MANY WERE REDUNDANT, AND I THINK THE FACILITATOR COULD HAVE SUMMARIZED & MOVED ON.

5. Did you think we accomplished the objectives set out for the workshop?
YES (IN TERMS OF IDENTIFYING USER NEEDS (eg BOB WOOD) AND SENSOR TECHNOLOGIES).

6. Did you think the format was conducive for eliciting ideas from both the users and researchers?
I THINK THE END-USERS SHOULD HAVE ALSO BEEN "RUN" THROUGH THE "GAUNLET" TO GET A MORE STRUCTURED UNDERSTANDING OF WHAT THEY NEED. AS IT WERE, WE LISTENED TO THE USERS DESCRIBE THEIR PROBLEMS IN A "SPOTTY" FASHION. PERHAPS NEXT TIME THE END-USERS & DEVELOPERS SHOULD BE GIVEN A LIST OF QUESTIONS (GAUNTLET) BEFORE THE MEETING TO ANSWER AND PRESENT AT THE MEETING. INCLUDE QUESTIONS ABOUT EXISTING SENSORS IN SIMILAR AREAS.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
9.

Please provide any comments that will help us improve on the next workshop!
SEE COMMENTS IN 6, 4, 5

DOE Sensor Workshop Evaluation/Comment Sheet

Developer

1. Which Breakout Session did you primarily attend? VOC

2. What was/were the most valuable ideas that came out of the workshop? - Commercialization is a serious roadblock - fails even when successful

3. What was/were the most important recommendation that came out of the workshop? Partnerships, leverage funding,

4. What did you like best about the workshop? heated discussions - what works, what doesn't.

5. What did you like least about the workshop? · focus on gadgets over systems

5. Did you think we accomplished the objectives set out for the workshop? No. - still to big of a step to get to LTM program plan.

6. Did you think the format was conducive for eliciting ideas from both the users and researchers? Mostly - a little too much domination by a few people.

7. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).
   8

Please provide any comments that will help us improve on the next workshop!
Need to get definitions out early. LTM, "system", sensor, measurement,

Purdy, Caroline

From:	Lance Voss [Lance_Voss@nmenv.state.nm.us]
Sent:	Tuesday, June 19, 2001 3:44 PM
To:	purdyc@ctc.com
Subject:	Sensor workshop

Caroline,

I spoke to you briefly during the sensor workshop in Orlando and you asked that I provide my thoughts (in a paragraph) to be captured in the workshop report. Overall I think that the workshop functioned well in bringing together developers, users and supporters to discuss sensor and monitoring needs or development status. However, a problem did surface in that the workshop participants did not have a common vision of Stewardship and/or Long Term Monitoring program needs, there was (and Nationally is) no framework or programmatic context within which to evaluate monitoring and/or sensor needs. Workshop user needs ranged from initial or expanded site characterization, to remedial process monitoring and control, post remediation change of state detection. In the future, I would recommend a more integrated program, which would include participation by DOE Office of Long Term Stewardship, supporting a discussion of the evolving, programmatic Stewardship plans. This would allow the development of a consensus conceptual model for stewardship, which would identify issues such as end state and required monitoring functions. Considerations for monitoring may include, contaminant migration pathways, exposure pathway monitoring, risk evaluation and remedial process monitoring, and integrator operable unit monitoring on a landscape level within prescribed end state. Any future workshops may also benefit from an expanded US EPA participation relative to stewardship needs. The combined DOE, DOD, EPA (Brownfields, etc) recognition of the overall scope of stewardship and LTS needs may be beneficial for developers relative to the commercialization and marketing potential for sensor technology.

I look forward to the workshop summary and continuing involvement.

Thanks,

Lance Voss
DOE Oversight Bureau
(505) 845-5825

DOE Sensor Workshop Evaluation/Comment Sheet

1. Which Breakout Session did you primarily attend?
Radionuclide mainly as a developer

2. What was/were the most valuable ideas that came out of the workshop?
Measuring the rad concentration is only part of the solution. I was pleased to see the acceptance of process monitoring (flow, biological, chemical), the value of qualitative measurements (ie yes/no rad detection), indicator monitoring (flux, pH, CO2, geophysics?), data interpretation (new methodologies to make use of this data), data collection frequency as a function of depth.

3. What was/were the most important recommendation that came out of the workshop?
Although this did not come out as a "recommendation", you really should focus your attention towards the radionuclides. DOE has a monopoly on this problem and my guess is that DOE will have to provide the research to solve it. Metals and VOCs can better be partnered with industry.

4. What did you like best about the workshop?
Nice food. I liked the informal atmosphere.

5. What did you like least about the workshop?
I feel that you asked the wrong question to the group. Although the functional requirements for sensors is important, it would have been more useful to ask "Where can LTM really make an impact to DOE?". For this question, you really need more users with some scientist to force them to think longterm. From this perspective, you have greatly focused the problem such that the functional requirements can be addressed. These issues must also be addressed from a $ standpoint.

6. Did you think we accomplished the objectives set out for the workshop?
I don't think that we have the user buy-in on long term monitoring. Operations has a fairly short term view of the DOE problem due to fighting brush fires and being awarded on short term performance. A "selling" program is needed to get the users (and those who regulate them) to support the value of LTM. Be careful on what project you initially and stress the value to the users.

There seemed to be a lack of thinking outside of the box. People were trying to replace 1/4ly GW sampling by putting sensors that can measure contaminant concentrations at laboratory detection limits down a well. Not very exciting and not very likely. I think the true value of LTM and sensors lie elsewhere and it should be the goal of the workshop to begin to identify these areas.

7. Did you think the format was conducive for eliciting ideas from both the users and researchers?
As with most workshops, it was frusterating at times. We probably could have gotten as far with less people. A summary report could have been made to the audience to get them on the same track to jump start the workshop.

8. How effective were the facilitators at drawing out discussions and ideas from the participants in your breakout group? On a scale of 1 to 10 (10 = extremely effective).

They seemed fine. Bill Haas seem to do the better of the two.

So there are my quick comments. Overall, not a bad start. Hope my comments were helpful.
Give a call if you want to talk about these issues more.
Earl Mattson
208 526-4084
matted@inel.gov

Please provide any comments that will help us improve on the next workshop

APPENDIX E: Applied Needs Statements

The entries in this table are related to monitoring or sample measurement needs. Only needs that fall under Work Package 1 and 11 in the SCFA program were included. (SC-01 = Characterization, Monitoring, Modeling, and Analysis; SC-11 = Validation, verification, and long-term monitoring of containment and treatment.) All duplicate needs were eliminated. The questions asked in the different columns were directed at only the monitoring or measurement need expressed in the Need Statement.

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Anaytical Performance Requirement
Need Code ID #	Need title	Narrative as stated by field office requesting need	A short description of the problem being addressed by need	Contaminant of concern as given in the need	Media of concern as given in the need (eg. soil, grout, groundwater etc.)	General description of the stage of development requested in the need (eg. gate of technology maturity)	Is the need focused on sampling or detection improvements or both?	Are there any functional requirements, specific to measurements, stated in the need?

APPENDIX E: Applied Needs Statements

Needs Statements Submitted to SCFA - WP1 and WP11

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
AL-00-01-03-SC	Cost-Effective means of Characterization and Remediation of HE-Contaminated Soils, Surface Waters, and Ground Waters	Cost effective methods of cleaning up soils contaminated with HE (particularly RDX and HMX) and metals (particularly barium). Methods for treatment of waters contaminated with HE and barium. Need methods that do not significantly increase waste volumes. Methods for characterizing transport pathways in canyon bottoms to support risk assessments at these sites. LANLs TA-16 contains multiple sites contaminated with high levels of high explosives (HE) and barium. Of these sites, the most significant is the outfall from HE machining building TA-16-260. Levels of HE at this site range up to 20 wt, and > 10 000 ppm. HE extend for over 500 ft down a small drainage. Total waste volumes at TA-16 sites are estimated at 4000 to 10000 cubic yards, depending on cleanup levels promulgated.	Contaminated soils, ground water and surface waters	HE (RDX and HMX) and metals (Ba)	soil, ground water, surface waters	Applied	Sampling and detection	Cost effective
AL-00-01-04-SC	Long-Term Monitoring Strategies and Techniques to Evaluate the Design of Material Disposal Area Engineered Covers	This is a Long-term Stewardship need. The current ER Road Map has speculated that capping and monitoring will be the preferred remedial alternative for many of the Material Disposal Areas at LANL. Some type of site stability monitoring is needed for the duration of the engineered cover life cycle. It is hoped that this monitoring can be performed concurrently with any contaminant monitoring which may be required by the NMED. Additionally, it is hoped that boreholes constructed during the investigation phase can be utilized for this purpose and provides cost savings.	Monitoring engineered barrier and disposal area for contaminants	"Contaminants"	Soils and groundwater	Applied	Sampling and detection	Monitoring in boreholes; concurrent monitoring of barrier and area surrounding disposal site
AL-01-01-04-SC	Long-term Stewardship and Monitoring of Water Retention Structures Emplaced after the Cerro Grande Fire	In May 2000, Cerro Grande Fire burned large areas of Los Alamos and surrounding property. As a result, water retention structures (e.g. dams) were constructed to protect LANL facilities and the Los Alamos community from flooding. Methods for long-term stewardship and monitoring to evaluate and predict the impact of recently emplaced retention structures on the environment and migration of hazardous substances currently within the soil.	Monitoring areas surrounding water retention barriers placed after LANL fire	"hazardous substances"	Soils and groundwater	Applied	Sampling and detection	Not given
AL-01-06-01-SC	Non-Conventional Subsurface Soil Vapor Studies for VOCs	Need the ability to detect subsurface VOCs without drilling, which could result in vapor migration to soil surface. The technology must be non-invasive, cost efficient, and reach depths to 450 feet. Pantex Plant recently discovered TCE contamination in the Ogallala aquifer, and high explosives have been detected in the perched aquifer.	Deep VOC subsurface contamination	VOCs	soil or ground water	Applied	Detection	Non-invasive method to detect up to 450 ft depth
AL-01-06-02-SC	Innovative Methodology for Identification of Abandoned Homestead Wells	According to the local population old homestead wells may exist on Pantex Plant that are currently not identified on site plans. The wells are iron cased and magnetic surveys have been tried unsuccessfully. Pantex Plant needs to determine the location of these suspected wells, to further understand potential subsurface pathways into the Ogallala aquifer. Pantex Plant recently discovered TCE contamination in the Ogallala aquifer, and high explosives have been detected in the perched aquifer.	Locating abandoned wells	No contaminant, wells	NA	Applied	Detection	Efficient detection
AL-01-06-04-SC	Toxicology Information for Triamino-trinitrobenzene (TATB) and dimethyl-formanmide (DMF) in Soils and Groundwater	No EPA protocol exists for TATB and DMF sampling. This deficiency is impacting the remedial field investigation stage that the site is undergoing. Pantex Plant recently discovered TCE contamination in the Ogallala aquifer, and high explosives have been detected in the perched aquifer.	Sampling protocol for TATB and DMF	TATB and DMF	soil, ground water	Applied	Sampling and detection	Toxicology and method development
AL-01-06-05-SC	Development of Physical and Conceptual Models Specific to the Pantex Plant Burning Ground WM Unit	Several question regarding subsurface geology and the impact of particular remediation strategies remain unanswered. Before selecting a baseline strategy, a well define geologic model needs to be developed and provided to Pantex Plant. Pantex Plant recently discovered TCE contamination in the Ogallala aquifer, and high explosives have been detected in the perched aquifer.	Conceptual Models for Pantex	NA	soils	Applied	NA	geology characterization

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AL-07-09-02-SC	Hydrologic Performance Monitoring of Engineered Covers	This is a Long-term Stewardship Need. 3 Grand Junction Office programs involve isolation of radioactive and other hazardous materials in landfills: Long-Term Surveillance and Maintenance (LTSM), Uranium Mill Tailings Remedial Action-Ground Water, and the Monticello Remedial Action Program. The success of all three programs rely on the performance of engineered covers which have already been constructed or are being constructed. Efficient and preferably non-destructive methods are needed for monitoring the hydrologic performance of compacted soil layers (CSLs) and capillary barriers in both existing and planned landfill covers. LTSM will eventually monitor 24 Title I uranium mill tailings disposal facilities and other radioactive and hazardous materials landfills across the country.	Monitoring caps for UMPTRA landfills	Hazardous substances and radionuclides	Landfill covers - soils and groundwater	Applied	Sampling and detection	Non-destructive methods for monitoring hydrologic performance of covers
AL-08-01-16-SC	Cost Effective Technologies for Addressing TRU in Soils and Sediments	Innovative and cost effective technologies are needed to address TRU in soils and sediments, mostly in material disposal areas in Technical Areas 21, 49, and 54. : Potential movement of TRU by surface runoff, soil erosion and infiltration into stream channels, and by subsurface flow into the regional aquifer.	Remediation and monitoring need: TRU runoff or infiltration into stream channels and aquifer	TRU materials	Soils and groundwater	Applied	Sampling and detection	"innovative and cost effective"
AL-09-01-04-DD-S	Methodology for Effective D&D of Large Environmental Sites	Non-invasive decontamination agents are needed for decon of low-fired and medium fired PuO2 in soils and materials. This methodology must selectively remove the Pu from the soils and materials without dissolving the matrix. The overall process must be applicable to large sites and must not generate large volumes of secondary waste. Fundamental Scientific Understanding Needed: The selective dissolution of PuO2 in a complex matrix with a decon solution that is rapid (<10 min) and non-invasive to the matrix being deconned. The fundamental reactions and compounds that are both effective and selective in accomplishing this need.	Remediation - Decontamination of soils and materials	PuO2	soils and building materials	Applied	NA	non-invasive decon
AL-09-01-13-DD	On-Site Quantitation of Plutonium and Americium in Soil and Concrete Ruble from D&D Projects	Short/long term need for new technology applicable to D&D projects to analyze radioactive debris and rubble in real time at the generation. Several areas such as Technical Areas 21 and 33 contain structures and soil contaminated with Plutonium and Americium. The demolition will produce materials that may contain hazardous levels of contaminated debris. Whether this debris is left in place or sent to a disposal facility will depend on the concentration of Pu and Am. Soils containing sufficiently low levels of radionuclides may be left in place. Presently, analysis of building debris and soil samples require the capabilities of a fixed radioanalytical laboratory. These analyses require at least days and usually five days from the time the laboratory receives the samples.	D&D projects - measure contamination in soils and concrete rubble	Pu and Am	Soils and debris	Applied	Sampling and detection	Real-time analysis
AL-09-02-01-SC	Long-term Site Monitoring System	This is a Long-term Surveillance and Maintenance need. Monitoring of sites will be required for a 30 to 100 year period after completion of initial characterization and remediation actions. The installation, maintenance, and data management of systems to perform this monitoring function represent a significant long-term liability (cost and compliance). While systems currently exist for performing this monitoring function, there is a major opportunity for making improvements that have tremendous potential for reducing costs and risks.	Cheaper long term monitoring - very general	Not given	Not given	Applied	NA	"A LTM system"

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AL-09-02-02-SC	Environmental Restoration (ER) Site Hazard Information System	This is a Long-term Surveillance and Maintenance need. A system is needed to provide hazard information related to an installations ER sites to current and future site personnel. This system should provide reliable, real-time data to personnel on Department of Energy sites who have the potential to be exposed to contaminants from inadvertent events or intrusions to existing or previously remediated ER sites. Current methods of providing data to site personnel may not ensure that accurate information is available to critical users in a timely manner, particularly for certain groups such as emergency first responders. This need fits both the technology opportunity category and the technology need category.	Providing monitoring info for remediated sites	"Contaminants"	Not given: implied all media	Applied	Sampling and detection	reliable, real-time monitoring info
AL-09-02-03-SC	Landfill/ Surface Covers	This is a Long-term Stewardship need. Cover alternatives with supporting design, implementation, maintenance, and monitoring guidance are required for containing contaminants at legacy sites where immediate or active remediation is not the most appropriate action. Surface covers are planned for closure actions at three locations on the Sandia National Laboratories/ New Mexico site. These three locations are the Mixed Waste Landfill (MWL), the Chemical Waste Landfill (CWL), and the disposal cell at the corrective action management unit (CAMU).	Monitoring landfill covers	"Contaminants"	Disposal cell covers - soils	Applied	Sampling and detection	Not given
AL-09-02-04-SC	Natural Attenuation Protocols for Supporting Final Closure of Contaminated Sites	This is a Long-term Stewardship need. Since many remediated sites will not be cleaned up to original background levels, protocols are required to establish how natural attenuation processes will affect remaining contaminant migration over the long-term. Many environmental restoration operable units will not be cleaned to background levels. For example, the Chemical Waste Landfill (CWL) will be excavated to a specified depth with the excavated material treated prior to disposition.	Protocols for NA remediation	"Contaminants"	Soils and groundwater	Applied	Protocols - NA	NA
ch-ss04-99	Long-Term Groundwater Monitoring	BNL groundwater is contaminated by strontium-90, tritium and VOCs. These long term monitoring needs require enhanced or new monitoring techniques that allow reliable, quick and inexpensive groundwater analysis. In addition, efficient methods for data management and interpretation are needed.	Cheaper, reliable, quick GW analysis	Sr-90, tritium, and VOCs	Groundwater	Applied	Detection	"Cheaper, reliable, quick"
CH-SS06-01	New Tools for Long-Term Monitoring of Groundwater Quality and Groundwater Flow Conditions at ANL-E	ANL-E is developing a Long-Term Stewardship (LTS) program that will be fully implemented after remedial actions work is complete in 2003. New tools for long term monitoring of groundwater quality and groundwater flow conditions are needed to ensure that this program is reliable and cost effective and that information generated by this program is managed properly.	GW quality and flow conditions	Not given	Groundwater	Applied	"New tools" - implied detection	New tools for monitoring GW: reliable and cost effective, data management effective
ID-1.2.08	Improved rise-time peak discrimination software for CdZnTe gamma ray spectrum detectors		Improved software for CdZnTe gamma detectors	SNF	SNF	Applied	Detection	Improved rise time peak discrimination software
ID-6.1.01	In-Situ Debris Characterization for Partial Retrieval	Because it may be necessary to process the soil as well as the buried waste of a pit or trench, instrumentation capable of in place real time characterization will be needed to expedite waste processing decisions.	Waste processing - in situ characterization	"Buried waste"	Soil and buried waste	Applied	Sampling and detection	In place, real-time
ID-6.1.02	Real-Time Field	Instrumentation that is capable of real time identification of groundwater and soil contamination, the extent of contamination, verification of soil contaminant concentrations versus risk-based levels.	Real time detection of contamination to determine extent of contamination	"contaminants"	Soil and groundwater	Applied	Sampling and detection	Real-time analysis

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ID-6.1.26	Capability for Real-time Sorting of Soil and Debris Based on Organic, Toxic Metal, HE, or Radionuclide Contamination	Because it may be necessary to process the soil as well as the buried waste of a pit or trench, instrumentation capable of in place real time characterization will be needed to expedite waste processing decisions.	Processing waste retrieved from pit and trenches	Organic, toxic metals, HE, rads	Soil and buried waste	Applied	Sampling and detection	Real-time analysis
ID-6.1.27	Integrated Suite of In Situ Instruments to Determine Flux in the Vadose Zone	An improvement of both sensors and their installation technique is necessary to reduce the uncertainty in model predictions of the source term flux at the contaminant source.	Reduce uncertainty in model predictions	"contaminants"	Soil and groundwater	Applied	Sampling and detection	In situ measurements for models
ID-6.1.28	Drum and Box Assay Capability to Measure 10 nCi/g Distributed Contamination in Heterogeneous Matrices	In order to reduce treatment volumes of Pit 9, it is necessary to develop characterization instrumentation that is sensitive enough to discriminate between a wide variety of mixed substances at the level of 10 nCi/g .	NDE/NDA assay	"contaminants"	Drums or Box buried waste	Applied	Sampling and detection	NDE/NDA of heterogeneous waste - box and drum containers
ID-6.1.29	Instrumentation to Precisely Locate Subsurface Utilities and Stainless Steel Piping	A technology is needed to determine the location of underground ferrous and non-ferrous structures.	Detection of Fe and non-Fe subsurface utilities or pipes	Subsurface structures	soil	Applied	Detection	Geophysics for better detection of subsurface structures
ID-6.1.30	Instrumentation to Reliably Measure Soil Gas Flux Accounting for Barometric and Temporal Variations	Variations in atmospheric conditions cause gas contaminants to escape without detection. Instrumentation is needed that can measure the gas flux of the soil to better predict the behavior of these contaminants.	Soil gas flux	"gas contaminants"	Vapor or soil gas	Applied	Sampling and detection	measure soil gas flux
ID-6.1.36	Long-term Subsurface engineering Structures and Monitoring Methods for Permanent Control of Residual Contamination and Waste Left In Place	Need to provide durable subsurface containment structures and monitoring systems for permanent control of residual contamination and waste left in place. Subsurface containment structures shall include systems such as horizontal barriers, vertical barriers, tanks, vaults, treated monolith waste forms, and landfill liners; and shall exclude caps (covered under separate need). The sensors shall monitor structural integrity over time and contaminant (leachate and vapor) migration. Engineered structures and sensors shall withstand natural phenomena, be durable, be maintainable/reparable, and be amendable to future actions (if required by changing requirements).	Monitor containment integrity and leachate and vapor migration	"contaminants"	leachate and vapor	Applied	Detection	"Durable, maintainable, repairable
ID-6.1.37	Real Time Detection of Contaminant using In-Situ Sensors	Devices or sensors are needed to detect below ground releases in the vadose zone from leaks, spills, or releases of contaminants before reaching ground/surface water. The envisioned device will be field rugged, long-lived, require minimal maintenance, and networked via wireless technology to a central alert system. Either a subsurface device installed in boreholes and burial pits or a surface geophysical imaging device will be acceptable. A variety of organic, inorganic and radioactive contaminants require long-term monitoring. The primary shortcomings for ground water monitoring are the expense and lag between the release to the environment and detection. Rapid detection of contaminant release will ease stakeholder concerns over hazards left in place after clean up.	Vadose Zone monitoring; detect subsurface leaks, spills or releases	"contaminants" "variety of organic, inorganic, and rads	Groundwater	Applied	Sampling and detection	Field rugged, long lived, minimal maintenance, rapid detection, networked via wireless tech, installed in boreholes.
ID-6.1.38	Leachate Detection and Collection As A Backup System	Need to develop an in situ technique or approach to detect monitor leachate accumulation within any buried waste. The sensors shall monitor structural integrity over time and moisture and contaminant (leachate and vapor) migration overtime. Engineered structures and sensors shall withstand natural phenomena, be durable, be maintainable/reparable, and be amendable to future actions (if required by changing requirements). The sensors should also require limited to no maintenance, have low power demands, and have either long-term data storage or remote data transmission capabilities.	Monitor containment integrity and leachate and vapor migration	"Buried waste"	leachate and vapor and structural integrity	Applied	Sampling and detection	In-situ, no maintenance, low power, remote data transmission, long term data storage

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ID-6.1.39	Long-term Subsurface engineering Structures and Monitoring Methods for Permanent Control of Residual Contamination and Waste Left In Place	Need to provide durable subsurface containment structures and monitoring systems for permanent control of residual contamination and waste left in place. Subsurface containment structures shall include systems such as horizontal barriers, vertical barriers, treated monolith waste forms, tanks, vaults, and landfill liners; and shall exclude caps (covered under separate need). The sensors shall monitor structural integrity over time and contaminant (leachate and vapor) migration. Engineered structures and sensors shall withstand natural phenomena, be durable, be maintainable/reparable, and be amendable to future actions (if required by changing requirements).	Monitor structural integrity of containment structures and contamination	Buried waste	leachate and vapor and structural integrity	Applied	Sampling and detection	Sensors durable, maintainable, repairable
ID-6.1.40	Sensor Array In SDA to Detect Moisture Infiltration	Need to develop a sensor array that can be placed over any buried waste to detect and monitor moisture infiltration. The sensors shall monitor moisture infiltration through the cover material over the buried waste over the lifetime of the institutional control of the site. The sensors shall withstand natural phenomena, be durable, be maintainable/repairable, and be amendable to future actions (if required by changing requirements). The sensors should also require limited to no maintenance, have low power demands, and have either long-term data storage or remote data transmission capabilities.	Monitor moisture infiltration for Landfill Cap or cover for engineered containment structure	Moisture	Soil or synthetic landfill caps	Applied	Sampling and detection	Sensors durable, maintainable, repairable, low power demands, remote data transmission capability
ID-6.1.41	Design and Determine Durability of a Closure Cap and Monitoring System	Need to design a closure cap and monitoring system to maintain cap integrity over the long-term (i.e., 1000-year life). Also need to determine the durability of a cap system with respect to retention rates, dispersivity, plant uptake factors, bio-accumulation rates, fracture flow rates, and boundary conditions.	Primarily a need for closure cap design, but monitoring systems	Moisture	Soil or synthetic landfill caps	Applied	Sampling and detection	No specifics
ID-6.2.26	Long-term information and records management system	As identified in numerous DOE LTS strategic documents, Agencies, affected municipalities and individual stakeholders have recognized the need to archive site specific information and data in a durable, robust, retrievable format for future generations. With the likelihood that organizational responsibilities will change over time, this need includes necessary records management processes and techniques to ensure proper transfer of records across Agencies and to individual stakeholders.	Records and info management	NA	NA	Applied	NA	NA
ID-6.2.29	Multi-Media Contaminant Monitors and Improved Diagnostic Parameters	A need exists to develop improved sensors and define better diagnostic parameters to identify and characterize the presence of contaminants in all media.	Improved sensors	"contaminants and other diagnostic parameters"	All media	Applied	Sampling and detection	"Improved sensors"
ID-7.1.02	Capability to Monitor Contaminant Movement Under an Inactive Facility/Structure Left in Place	Contaminant movement under facilities/structures particularly inactive structures is not being done adequately which leads to potential violations of RCRA and could compound CERCLA. There is a need to have remote monitoring capability to detect all different types of contaminants that could be moving. The equipment needs to be reliable and long lasting. The equipment needs provide real time data to a remote location via a PC and include alarm points as well as grafting ability.	Monitoring all contaminants under building/structures	all contaminants	All media	Applied	Sampling and detection	Remote monitoring capability, reliable, long lasting
ID-7.2.06	Remote Characterization for Building Release, Large Area Surface Soil Characterization, and Characterization of Sumps, Debris, Underwater Areas, and Buried Pipes and Utilities	The INEEL needs a field deployable characterization equipment that is accurate and economical to use.	Field deployable characterization equipment - very broad	Not given	All media, buildings, piping, sumps	Applied	Sampling and detection	accurate, economical

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ID-S.1.04	Real-time Field Instrumentation for Characterization and Monitoring Soils and Groundwater	Instrumentation that is capable of real time identification of groundwater and soil contamination, the extent of contamination, verification of soil contaminant concentrations versus risk-based levels.	Real time detection of contamination to determine extent of contamination	"contamination"	Soil and groundwater	Applied	Sampling and detection	Real-time analysis
ID-S.1.17	Development of Sensors for Large Scale Measurements in the Vadose Zone to Define Spatial Variability	Sensors need to be developed that measure at a larger scale to better represent the data needs of numerical models.	Sensors for large scale areas in vadose zone	Not given	Soil and groundwater	Applied	Sampling and detection	Large scale coverage
ID-S.1.18	Development of Indirect Sensing Instrumentation for Spatial Variability Analyses of State Variables	Sensors need to be developed that allow indirect sensing of state variables (e.g., moisture content, pressure head, and contaminant concentration) between boreholes to account for spatial variability, thus providing a more representative measurement of the phenomena.	Sensors for state variables (i.e.. moisture, pressure, etc) between boreholes	Not for contaminants	Soil and groundwater	Applied	Sampling and detection	NA
ID-S.1.19	In Situ Biologic Activity Sensor for Vadose Zone and Groundwater Monitoring, Characterization and Remediation	Currently, inadequate instrumentation exists to measure the amount of and rate of natural biodegradation that occurs in the vadose zone.	Sensors for NA	Not given	Soil and groundwater	Applied	Sampling and detection	Not given
ID-S.1.27	Enhanced sensitivity and capability of in-situ and ex-situ instruments	Many in-situ and ex-situ instruments are currently on the market to measure contaminants in all media. The sensitivity of the instruments and the analytical suite are limited and not fully developed. Instrumentation needs to be developed/enhanced that includes more analytical capabilities and satisfies regulatory required limits.	Increased sensitivity of analytical measurements	"Contaminants"	All media	Applied	Detection	Increased sensitivity, in-situ and ex-situ measurements
ID-S.1.28	Develop instrumentation to determine specific alpha and beta isotopes more quickly	Measurement of specific alpha and beta isotopes is time consuming and slow; it can take many weeks to receive the results. There is a need to develop instrumentation, both in the laboratory and in the field, to more rapidly determine specific isotopes for all media. Ideally, real-time analytical techniques and equipment could also be developed.	Real-time analytical techniques for alpha and beta emitting isotopes	"Specific alpha and beta isotopes"	All media	Applied	Detection	Real-time analysis for rads (no mention of specific isotope)
ID-S.1.39	In Situ Grout Integrity Sensors	Need to develop sensor(s) that can be deployed within buried waste during grout emplacement. The sensors need to provide data relative to; presence of void spaces; migration/changes of moisture content and associated geochemical (Eh/pH) data; formation of fractures/other voids; subsidence of the grouted area. The sensors shall withstand natural phenomena, be durable, easily deployed either prior or during grouting, and provide full coverage throughout grouted area at relative low cost. The sensors should also require limited to no maintenance, have low power demands, and have either long-term data storage or remote data transmission capabilities	Sensors emplaced in grout waste form to monitor grout integrity	NA	grout	Applied	Detection	Sensors for moisture, pH, Eh, etc.: no maintenance, low power demands, remote data transmission
NV01	Down-Hole, Real-Time Monitoring of Radiation (mainly tritium) in Boreholes	An instrument to perform daily, in-situ, low-level radiation measurements in deep monitoring wells (800 to 5,000 ft) at remote locations. Tritium is the principal radionuclide. Other needed measurements are temperature, pH, electrical conductivity, water level, and total gamma.	Tritium measurements in deep monitoring wells	Tritium	Soil and groundwater	Applied	Sampling and detection	In-situ, real time analysis, downhole, 800-5,000 ft depth
NV02	Deep Well Monitoring (former NV02-0001-02S)	Cost-effective well design and sampling technologies are needed for sampling groundwater for radionuclides and other physical and chemical parameters in deep (up to 1,500 meters) wells in remote areas. Current methods may perturb the in situ conditions to the extent that unrealistic solution chemistry and colloidal concentrations may be detected or in other ways results in samples whose analytical results are unrepresentative of formation waters at depth.	Better sampling technologies for better representative samples	Radionuclides	Groundwater	Applied	Sampling	Sampling in deep wells, remote locations

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NV18	Long-Term Monitoring of Moisture Content as a Precursor in Contaminant Transport in the Vadose Zone and Closure Covers (former NV18-0001-07S)	Contaminated industrial sites and operating low-level radioactive and mixed waste sites are located in arid alluvial valleys where the groundwater table is between 500 to 1600 feet below the surface. The exceptionally thick vadose zone at these locations mandates development of efficient monitoring systems that can: 1) verify site conditions documented in site characterization and performance assessment studies; and 2) provide early warning of an increased potential for migration of hazardous and radioactive contaminants. Cost-effective monitoring systems that meet these requirements need to be designed, demonstrated, and deployed at hazardous and radioactive waste management site(s) on the Nevada Test Site (NTS). No method for measuring the concentration of tritium is currently available.	Efficient monitoring system for moisture in vadose zone	Moisture	Soil/Vadose zone	Applied	Sampling and detection	Deployment in deep vadose zone
NV23	Radiological Contamination Detection Capability (former NV23-0001-11)	A method is needed to locate and identify radioactive waste in the subsurface which minimizes the amount of waste generated and minimizes the potential for worker exposure. Radioactive contamination buried beneath several feet of earth is hidden from surface detection and effectively shielded. The Spectral Gamma Probe and Cone Penetrometer technology has been successfully used to detect radioactive waste in a landfill and to identify areas where confirmatory sampling should be completed. Some improvements in calibration, detection/radionuclide identification, measurement, and soil penetration are needed. There are six to ten sites in Area 25 of the Nevada Test Site (NTS) including landfills, dumps, and leach fields which could benefit from this technology.	Detection in subsurface of rads; and better sampling to reduce secondary waste generated	Radionuclides	Soil and groundwater	Applied	Sampling and detection	Sampling in landfills, dumps, leach fields. CPT is considered baseline, need improvements to detect in subsurface
OH-153	Onsite Disposal Facility Leachate Flow Monitoring	Need a flow monitoring system for the leachate collection system from the onsite disposal facility at Fernald to monitor the rate of flow of leachate. The system should be capable of remote monitoring and recording of data. The system should be automated for operation after the site is closed and personnel are located remotely.	Monitoring leachate flow at disposal facility	Not given	Leachate	Applied	Sampling and detection	Automated, remote monitoring system
OH-AB-012	Detection of Tc-99 in Soils	Tc-99 exists as a contaminant in AEMP soils which are being excavated for processing in the soilwashing plant. As soils from the wetter areas (Area C - lower and west) are excavated increasing levels of Tc-99 are being detected that range from 3 pCi/g to >100 pCi/g. These ranges can become unacceptably high and lead to an additional secondary waste stream, which will reduce the efficiency of the soilwashing plant. Soils contaminated with excessive levels of Tc-99 need to be detected and segregated so that proper management decisions (i.e. process additives, system modifications, or direct disposal) can be made on a real-time (< 1 hr) basis. The problem is that the AEMP closure budget and schedule are threatened. FEMP need OH-F004 is taking the lead on this.	Real-time detection of Tc-99 in soilwashing process	Tc-99	Soils	Applied	Sampling and detection	Real-time = <1 hr, 3 to >100 pCi/g
OH-AB-013	Sub-Slab Characterization and Sampling	Based on results of ongoing surveys of legacy waste boxes, excavated soil conditions near the buildings, and unplanned events during remediation, there may be significant chemical (i.e. TCE, PCB) or radiological contamination below the AEMP main plant slabs. If major amounts of contaminants are found, the baseline soil washing process may need to be modified to remove chemical contaminants also. The problem is that the AEMP closure budget and schedule may be threatened.	Sampling below building slaps	TCE, PCB, and rads	Soils and groundwater	Applied	Sampling and detection	Access to subsurface underneath slabs

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OH-F003	Non-Intrusive Location of Buried Items	A device for location of buried objects in clayey soils.	Detection of buried objects in clay soils	NA - buried objects	Soils	Applied	NA	Geophysics for better detection of subsurface structures
OH-F004	Technitium-99 Detector/Analyzer	Laboratory analyses for Technetium-99 in soil presently takes three days. A detector or analyzer that can measure Tc-99 in the field and gives results in a few hours or less is required.	Tc-99 measurements in field	Tc-99	Soils	Applied	Sampling and detection	In-situ measurements, measurement rate <few hours
OH-F035	Enhanced Sensitivity Radon Meter	The Pylon Radon Monitor presently in use is capable of detecting as little as 1 pCi/L of Rn-222 in a one hour measurement. A detection limit of 0.1 pCi/L is desired to ensure meeting proposed federal regulatory compliance.	Radon detector to 0.1 pCi/L sensitivity	Radon	All media implied	Applied	Detection	Sensitivity down to 0.1 pCi/L
OH-F037	Improved In Situ Determination of Uranium & Other Gamma Emitting Radionuclides in Soil	Three improvements need to be made in the In Situ determination of Gamma emitting radioisotopes in soil. These are the ability to make accurate measurements in the presence of high background storage areas (where backgrounds could be five times higher than the activity being measured), in the presence of standing water or high moisture content (>50%), and in situations where there is considerable terrain variation, such as uneven slope, ditches, and foundation excavation.	Improvements in measurements for gamma emitting rads in soil	Radionuclides - gamma emitters	Soil	Applied	Sampling and detection	In situ measurements. 3 improvements: in high bkgrd; standing H20 or high moisture; uneven terrain
OH-F039	On-Site Disposal Facility Cap - Vegetative Cover	A vegetative cover system and management regime for the OSDF final cap that maintains the integrity of the cap and minimizes the need for long-term monitoring, maintenance, and repair.	Remediation need: Design disposal cell cap and management system: implied LTM system	Moisture	Cap vegetative cover - soil	Applied	minimize maintenance and repair	
OH-F048	Long-term Monitoring of Caps and Covers	Identify improved approaches for the long-term monitoring of the OSDF cover system	Improved methods and approaches for LTM of disposal cap	Not given - implied contaminants and rads	Closure cover - soils	Applied	Sampling and detection	not given
OH-F049	Non-Intrusive Location of Buried Wastes and Fill Material	Device for location of non-native, impacted materials in clayey soils.	Non-invasive detection of buried waste and fill material	Not given	Soil	Applied	Sampling	Implied: geophysics for detection of waste and fill material in clays
OH-F050	Long-term Monitoring of Leachate System	Identify Improved Approaches for the long-term monitoring of the leachate systems for the OSDF.	Monitoring of leachate system	Not given	Leachate	Applied	Sampling and detection	Long term duration
OH-F052	Long-term Treatment and Monitoring of Leachate	System for the stand-alone treatment and monitoring of leachate	Primarily a treatment need, monitoring of treatment of leachate	Not given	Leachate	Applied	Sampling and detection	Stand-alone system
OH-F101	Method of gathering data on uranium species and distribution in aquifer sediments for groundwater restoration	Geochemical information is required on the uranium species and their distribution in the aquifer sediments to support an accelerated groundwater restoration program. This information may accelerate the cleanup schedule and reduce project costs.	Detection of uranium species in aquifer sediments	Uranium species	Soils and groundwater	Applied	Sampling and detection	Speciation of uranium: assume oxidation state and isotope
OH-F102	Multi-level monitoring wells to support accelerated groundwater restoration	Multi-level monitoring wells are needed to support an accelerated groundwater restoration program. These wells are critical to gaining a better understanding of the dispersion of uranium within the aquifer.	Uranium detection at various depths	Uranium	Soils and groundwater	Applied	Sampling and detection	Depth profiles of uranium

APPENDIX E: Applied Needs Statements

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Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
OH-F111	Field characterization method for containerized excess sample material	FEMP has excess sample material in small containers returned from contract labs that is stored in drums. This material is uncharacterized and must be segregated for proper compatibility/treatment/disposal. A field method for characterization is needed to reduce the project schedule and costs associated with lab analyses of this material.	Characterization of secondary waste generated from lab analyses - field method	all contaminants	Soils	Applied	Sampling and detection	Field measurements for soil wastes in containers
OH-F154	Meteorological Monitoring Station	A fully automated meteorological monitoring station is needed as part of the long term post closure stewardship program at Fernald. The station should be capable of remote operation and retrieval of data. Internet connection for real-time data acquisition is desirable. Also, the system should be capable of being updated as technological advances are made.	Automated meteorological monitoring station	NA - meteorological data	NA	Applied	NA	NA
OH-F162	Non-destructive Assay/Chemical Fingerprint of Waste Streams in the Field	The current method of sampling and laboratory analysis is slow and costly. There is a need for a non-destructive assay method for the characterization of waste streams in the field. This would save time, cost, and additional handling and storage of waste containers awaiting laboratory analytical results.	NDA/chemical fingerprint measurements of waste streams	all contaminants	"Waste streams" - implies all media	Applied	NDA sampling and detection	In-situ measurements
OH-F198	Removal of uranium in groundwater	Groundwater extraction wells are in use for aquifer restoration (uranium removal.) The current method is a pump and treat system followed by reinjection of the water into the aquifer. An improved method of uranium removal/reduction in mobility would reduce the project schedule and costs.	Remediation need - removal of U from groundwater	Uranium	groundwater	Applied	NA	NA
OH-M907	Counting System Accepts a Slug	Develop a counting system that can accept a soil slug (e.g. from a geoprobe in a plastic tube), not require sample preparation, and give a radioisotope characterization sufficient to withstand the rigor of verification sampling QA/QC.	Improved counting measurements for radioisotopes	Radioisotopes	Soils in containers	Applied	Rad counting detection	Counting measurements outside containers
OH-M908	Portable Unit for Field Samples	Develop a portable unit that can be used for preparing soil samples in the field by drying, homogenizing them, and placing them in a container for analysis. This development should withstand the rigors of verification sampling standards. The unit will be used primarily for preparing soils containing plutonium and thorium for gamma spectroscopy or other counting methods.	Preparation of soil samples in field	Pu and Th	Soils	Applied	Sampling	Rad measurements (gamma) in field
OH-WV-911	Permeable Treatment Wall Design and Construction	Mitigating strontium-90 (Sr-90) contaminated groundwater and saturated soil on the North Plateau of the West Valley Demonstration Project (WVDP) is necessary. A pump and treat system installed as an initial mitigative effort to collect and treat groundwater and prevent it from surfacing in low lying areas has resulted in significant operations and maintenance (O&M) costs. Expansion of the pump and treat system would be needed to fully capture the contaminated groundwater plume, which would further increase O&M costs. Another means of more fully capturing the Sr-90 contaminated groundwater that has lower O&M costs is needed, such as a permeable treatment wall.	Remediation need - permeable treatment wall	Sr-90	Soil and groundwater	Applied	NA	NA
OK00-04	Removal of Subsurface VOC Contaminants in Low Permeability Soil Intermixed with Fractured Rock	Cost effective technology for cleanup of low permeability material contaminated with high concentrations of industrial solvents such as perchloroethylene and trichloroethylene.	Remediation need - removal of VOC from low permeable soils	VOCs - TCE and PCE	Soils	Applied	NA	NA
OK01-26	In Situ Long-term Monitoring of Tritium in Ground	To identify a monitoring technique that will allow for real-time evaluation of the tritium plume concentrations and location status in situ so as not to increase short term exposure risk.	Subsurface Tritium monitoring system	Tritium	Soils and groundwater	Applied	Sampling and detection	In-situ measurements, real-time, long term

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OK01-27	Long-Term Ground Water Monitoring	To identify new or enhanced, reliable, quick, and inexpensive method(s) to obtain scientifically defensible ground water data. As ground water monitoring will be required for up to 70 years at the site, the identification of new monitoring techniques that could significantly reduce cost and/or risk would reduce DOE's long-term liability.	LTM methods for Groundwater Data	Not given	Groundwater	Applied	Sampling and detection	"reliable, quick, inexpensive"
OK01-29	Accurate Field Analysis for PCBs	Technology to Perform Field Analysis of PCB Levels Compatible with Cleanup Levels and Regular Requirements	PCB field measurements at cleanup levels	PCBs	Soils and groundwater	Applied	Detection	Detection range: cleanup levels
OK01-31	Technology for In-Situ Long-Term Monitoring of Volatile Organic Compounds	Identify a technology to quantify ground water VOC concentrations in-situ.	In-situ measurements of groundwater VOCs	VOCs	Groundwater	Applied	Sampling and detection	In-situ, long term
OK99-01	Characterization and Removal of DNAPLs and LNAPLs from Soil and Groundwater	To identify a rapid and cost-effective remediation technology that can perform a well-controlled VOC DNAPL and LNAPL removal from finer-grained sediments and ground water.	Primarily a remediation need: removal of VOC in soils and GW	VOC - DNAPL & LNAPL	Soils and groundwater	Applied	Could imply sampling and detection	Not given
OK99-21	Monitor Tritium In-situ in Groundwater	To identify a monitoring technique that will allow for real-time evaluation of the tritium plume concentrations and location status in situ so as not to increase short term exposure risk.	Monitor tritium plume	Tritium	Groundwater	Applied	Sampling and detection	Real-time, in-situ
OK99-23	Field Surveillance Device for Detection of Radium-226	A non-labor intensive, field deployable device to survey a two plus acre site and detect Radium-226 activity down to 2 feet below ground surface for as low as 0.6 picoCuries/gram	Field deployable Ra-226 measurements	Ra-226	Soil and groundwater	Applied	Detection	broad coverage (2+ acres), down to 2 ft bg, detect to 0.6 pCi/gm
ORBW-03	In Situ Assay Systems	In situ assay systems with capabilities to non-intrusively or slightly-intrusively detect buried/contaminated materials.	Detection and assay of subsurface contaminated materials	"Contaminated"	Soil and groundwater	Applied	Detection	Non-intrusive or minimally intrusive in-situ assay system
ORBW-14 and 14a (Same)	Retrieved Waste Sorting	Advanced sorting and assaying of retrieved waste using batch or continuous systems.	Assaying retrieved waste	Not given	Not enough info	Applied	Detection	Continuous or batch assay systems
ORBW-19 and 19a (same)	Remediation of Secondary Soil Contamination	Technologies for the characterization and remediation of soil contaminated with radionuclides, mercury, and/or volatile organic compounds.	Primarily a remediation need: characterize contaminated soil	Radionuclides, Hg, VOCs	Soil	Applied	Sampling and detection	Not given
ORHG-03	Nondestructive Mercury Detector for Soils	Nondestructive, nonintrusive, real-time, quantitative mercury detector for screening contaminated soil.	Hg detector for screening contaminated soil	Mercury	Soils	Applied	Sampling and detection	Non-intrusive, non-destructive, real-time measurements
ORHG-16	Treatment of Mercury Contaminated Soil	Cost effective treatment of mercury RCRA characteristic mixed waste soils to RCRA alternate soil LDRs.	Treatment need: Hg in soils	Mercury	Soils	Applied	NA	NA
ORHY-01, 01a, 01b (same)	Dense Non-Aqueous Phase Liquid Source Characterization	Technologies for characterization of DNAPL in the subsurface.	Locating and characterizing DNAPL source in subsurface	DNAPL	Soils and groundwater	Applied	Sampling and detection	Not given
ORHY-02, 02a, 02b (same)	Low Waste Volume Exploration and Monitoring	Technologies for subsurface characterization, sampling, and monitoring that minimize waste generation.	Locating, measuring and monitoring waste in subsurface	Not given: implied buried waste materials	Soils and groundwater	Applied	Sampling and detection	Not given
ORHY-03, 03a, 03b (same)	Noninvasive Technologies to Identify Leaking Utilities	Technologies for location of areas of significant utility leakage.	Leak detection from utilities	Not given	Implied: All media	Applied	Sampling and detection	Not given

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ORHY-04, 04a, 04b (same)	Volatile Organic Compound Monitoring and Detection	Technologies for rapid, cost-effective field measurement and monitoring of volatile organic compounds in environmental media.	VOC detection and monitoring	VOCs	All media	Applied	Sampling and detection	Rapid, cost effective, field deployable, monitoring capability
ORHY-05	Karst Characterization and Transport	Technologies to find karst systems in the subsurface and assess contaminant transport therein.	Locate Karst; assess karst contaminant transport	"Contaminants"	Not given	Applied	Sampling and detection	Not given
ORHY-06	Fractured Media Flow Characterization	Technologies to predict fracture networks and groundwater flow and contaminant transport therein.	Detect fracture networks in fractured media; understand contaminant flow and transport	"Contaminants"	Fractured media	Applied	Detection	Implied: Geophysics for detecting fracture networks
ORHY-13, ORHY-13a, ORHY-13b (same)	Reactive Barrier Treatment Systems	Technologies for in situ treatment of groundwater using permeable reactive media.	Remediation need - permeable treatment wall	not given	groundwater	Applied	NA	NA
ORHY-21, 21a, and 21b (same)	Real Time Performance Assessment Monitoring	Technologies for real time in situ monitoring of groundwater and surface water.	Performance Assessment Monitoring	Implies: all contaminants	Groundwater and surface water	Applied	Sampling and detection	Real-time, in-situ monitoring
RF-ER06	Improved Methods for Sampling and Characterization Beneath Large Building Foundations	The site requires improved methods for characterizing soils and groundwater beneath large building foundations. Building foundations are comprised of thick slabs of reinforced concrete. Vehicle access into many of the buildings is limited, eliminating the possibility of conventional truck- or skid-mounted drilling techniques. In addition, many hand held boring techniques lack the power to drill through foundation slabs.	Improved methods for sampling and measuring contaminants beneath bldg slabs	Implied: all contaminants	Soils and groundwater	Applied	Sampling and detection	Access to subsurface underneath slabs
RF-ER08	Capping Design for Arid and Semi-Arid Climates	The Site requires caps compatible with arid environments to prevent further groundwater contamination and movement of contaminants that are not amenable to source removal. For final Site closure, three caps of 10 acres, 43 acres, and 13 acres are planned in the Industrial Area over the Solar Ponds, the 700 area, and the 300 area, respectively.	Remediation need - Development of cap designs for arid and semi-arid climates	Not given - implied moisture	soils	Applied	NA	NA
RF-ER11	Real-Time Monitoring of Plutonium and Americium in Sewage Treatment Plant Influent	If current draft language in the Site's National Pollutant Discharge Elimination System (NPDES) permit remains in the final permit, there will be a need to complete and report the results of a feasibility study for improving monitoring of radionuclides in the sewage treatment plant (STP) influent. Radionuclides mentioned in the draft language include plutonium, americium, uranium, and tritium, although plutonium and americium are the primary radionuclides of interest.	Monitoring influent for rads in sewage treatment plant	Pu, Am, U, tritium	Process water	Applied	Sampling and detection	Real-time, monitoring process treatment system
RF-ER13	Capping or Treatment (Stabilization) for the Rocky Flats Ash Pits		Remediation need - Stabilization need for Rocky Flats Ash Pits	Not given	soils	Applied	NA	NA
RF-ER14	Characterization/Detection/Verification of Non-Aqueous Phase Liquids (NAPLs)	The Site is interested in identifying improved technologies to identify the presence of NAPL phase contaminants in soils and groundwater contaminated with organic compounds. Several areas are known to contain elevated levels of organic contaminants. The recognition of the presence of a NAPL phase will significantly improve the remediation decision process.	Detect and measure NAPL phase organics in subsurface	NAPLs (organics)	Soils and groundwater	Applied	Sampling and detection	No specifics: for remediation decision process

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Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-DD052		Technologies are needed to centrally monitor (detect, spatially locate, and quantify) contaminants of concern in the soil around and under the 221-U Facility. Technologies are needed to verify that contaminants are being contained. This need includes the ability to place the monitoring equipment under the facility and under waste that may be placed exterior to the facility. The technology is needed for determining existing conditions as well as detection of contaminant releases in the future.	Sampling and monitoring around and under facilities	"Contaminants"	Soils	Applied	Sampling and detection	Access to subsurface underneath slabs
RL-SS02	Improved, Real-Time, In-line Detection of Carbon Tetrachloride in Process Water	Monitoring carbon tetrachloride by discrete sampling is costly and slow. In-line sampling with real-time monitoring of contaminant concentrations may support the construction of fully automated treatment systems that could substantially reduce operating costs.	In-line process monitoring of CCl4 for treatment system	CCl4	Process water	Applied	Sampling and detection	Real-time, monitoring process treatment system
RL-SS03	Improved, Real-Time, In-Situ Detection of Carbon Tetrachloride in Groundwater	Monitoring carbon tetrachloride by discrete sampling is costly and time consuming. In situ monitoring would reduce the labor-intensive process of sampling, handling, and shipping samples for analysis. Purge water production and associated disposal or treatment requirements would be minimized or eliminated. In situ monitoring would also aid in situations where monitoring site access is difficult and costly, or where conditions may pose safety hazards to samplers. In situ measurement in extraction, injection or monitoring wells would provide real-time monitoring of contaminant concentrations. In situ monitoring is also needed to support long term monitoring associated with long-term stewardship of the plume. (Also see Science needs RL-SS33-S, RL-SS34-S, and RL-SS36-S)	Real-time, in-situ monitoring in extraction, injection and monitoring wells	CCl4	Groundwater	Applied	Sampling and detection	Real-time, in-situ monitoring in wells
RL-SS05	Improved, Real-Time, In-line Detection of Hexavalent Chromium in Process Water	Monitoring hexavalent chromium is currently conducted by discrete sampling. In-line sampling with real-time monitoring of contaminant concentrations may support the construction of fully automated treatment systems that could also reduce operating costs.	Real-time, in-line monitoring of process water	Hexavalent Cr	Process water	Applied	Sampling and detection	Real-time, in-line monitoring process treatment system
RL-SS06	Improved, Real-Time, In-Situ Detection of Hexavalent Chromium in Groundwater	Monitoring hexavalent chromium by discrete sampling is costly and time consuming. In situ monitoring would reduce the labor-intensive process of sampling, handling, and shipping samples for analysis. Purge water production and associated disposal or treatment requirements would be minimized or eliminated. In situ monitoring would also aid in situations where monitoring site access is difficult and costly, or where conditions may pose safety hazards to samplers. In situ monitoring is also needed to support long term monitoring associated with long-term stewardship of the plume. (Also see Science needs RL-SS33-S, RL-SS34-S, and RL-SS36-S)	Real-time, in-situ monitoring in extraction, injection and monitoring wells	Hexavalent Cr	Groundwater	Applied	Sampling and detection	Real-time, in-situ monitoring in wells
RL-SS08	Improved, Real-Time, In-line Detection of Strontium-90 in Process Water	Monitoring strontium-90 by discrete sampling is costly and slow. In-line sampling with real-time monitoring of contaminant concentrations may support the construction of fully automated treatment systems that could reduce operating costs.	Real-time, in-line monitoring of process water	Sr-90	Process water	Applied	Sampling and detection	Real-time, in-line monitoring process treatment system

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RL-SS09	Improved, Real-Time, In-Situ Detection of Strontium-90 in Groundwater	Monitoring strontium-90 by discrete sampling is costly and time consuming. In situ monitoring would reduce the labor-intensive process of sampling, handling, and shipping samples for analysis. Purge water production and associated disposal or treatment requirements would be minimized or eliminated. In situ monitoring would also aid in situations where monitoring site access is difficult and costly, or where conditions may pose safety hazards to samplers. In situ measurement in extraction, injection or monitoring wells, well points, or in river substrate would provide real-time monitoring of contaminant concentrations. In combinations of horizontal and vertical profiling, this will provide highly accurate isopleths of contaminant concentrations to aid in fate and transport model	Real-time, in-situ monitoring in extraction, injection and monitoring wells	Sr-90	Groundwater	Applied	Sampling and detection	Real-time, in-situ monitoring in wells
RL-SS10	Improved Technologies for Detection/Delineation of Burial Ground Contents and Subsurface Geological Boundaries.	Improved technologies are needed for non-intrusive or minimally intrusive methods for identifying burial ground contents and delineating difficult to find waste sites. A large number of burial grounds and liquid waste disposal sites were created during fifty years of defense plutonium production, many of which have been covered with soil (surface stabilized) or have no surface expression. Documentation of materials that were placed in the burial grounds and exact location of some sites is incomplete. To aid in remediation planning, the contents and boundaries of a burial ground need to be determined to the best extent possible prior to excavation.	Non-invasive detection of burial ground boundaries and waste contents	Waste contents	Burial grounds	Applied	Sampling and detection	Non-intrusive or minimally intrusive detection of geological formations and waste - also geophysical need
RL-SS11	Cost-Effective, In Situ Remediation of Hexavalent Chromium in the Vadose Zone	Cost effective in situ remediation technologies are required to remove or immobilize chromium contamination that is believed to exist in the vadose zone at depths below 15 feet. (Also see Science needs RL-SS33-S, RL-SS34-S, and RL-SS36-S)	Remediation Need	Hexavalent Cr	Soils	Applied	NA	NA
RL-SS13	Improved, Real-Time Field Screening During Excavation for Heavy Metals with Emphasis on the Following: Lead, Chromium, Mercury, and Barium	Rapid, field screening techniques are needed to guide remedial excavation and to ensure that excavated materials meet waste acceptance criteria prior to disposal. Primary metal contaminants of concern include lead, chromium, mercury, arsenic, and barium.	Field screening of metals during excavation	Pb, Cr, Hg, As, Ba	Excavated material	Applied	Sampling and detection	Real-time field screening
RL-SS14	Improved, Real-Time Field Screening During Excavation for Radionuclides with Emphasis on the Following: Uranium, Plutonium, Strontium-90, and Technetium	Rapid, field screening techniques are needed to direct characterization, excavation operations, and release of material for transport to disposal. Field screening techniques for characterization and delineation will assure that high cost, site characterization laboratory analyses are optimized. These techniques will also help assure that operations at excavation sites remove all contaminated material and that excavated materials meet waste acceptance criteria prior to disposal. Primary radioactive contaminants requiring improved field detection sensitivities include uranium, plutonium, strontium-90 and technetium-99.	Field screening of radionuclides during excavation	U, Pu, Sr-90, Tc-99	Excavated material	Applied	Sampling and detection	Real-time field screening
RL-SS15	Improved, In Situ Characterization to Determine the Extent of Soil Contamination of One or More of the Following Heavy Metals: Hexavalent Chromium…	The extent of contamination in soil and burial ground sites is often poorly defined. A cost-effective technology that provides real-time, in situ measurement of heavy metals (hexavalent chromium, mercury, lead, nitrate, and sodium) at depth is required to better define the contaminant plume boundaries prior to remediation and also to support long-term monitoring for performance validation of the completed remediation activity. In situ monitoring is also needed to support long term monitoring associated with long-term stewardship of contaminated soils.	Identify contaminant plume boundaries and LTM of contaminated soils	Cr+6, Hg, Pb, NO3, Na	Soil	Applied	Sampling and detection	Real-time, in-situ, deep subsurface

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Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS16	Improved, In Situ Characterization to Determine the Extent of Soil Contamination of One or More of the Following Radionuclides: Uranium, Plutonium…	The extent of contamination in soil and burial ground sites is often poorly defined. A cost-effective technology that provides real-time, in situ measurement of radioactive contaminants (uranium, plutonium, cesium, cobalt, technetium-99, strontium-90, iodine, and selenium) in soils at depth is required to better define the contaminant plume boundaries prior to remediation and also to support long-term monitoring for performance validation of the completed remediation activity. Characterization of TRU is also needed for some 200 Area waste sites. In situ monitoring is also needed to support long term monitoring associated with long-term stewardship of contaminated soils.	Identify contaminant plume boundaries and LTM of contaminated soils	U, Pu, Cs Co, Tc-99, Sr-90, I, Se, TRU waste	Soil	Applied	Sampling and detection	Real-time, in-situ, deep subsurface
RL-SS18	Improved Detection and Segregation of TRU Waste (Debris)	Burial grounds in the 200 and 300 Areas received waste contaminated with plutonium and other TRU constituents. The final remediation methods for sites suspected of containing TRU waste has not been established. If excavated and disposed on site, waste soils or debris with more than 100 nCi of TRU contamination per gram of waste does not meet current waste acceptance criteria and would need to be segregated.	Detection and segregation of TRU waste during excavation	TRU waste (Debris)	Soil and debris	Applied	Sampling and detection	Detection range: low level - > 100 nCi
RL-SS19	Detection, Handling, and Treatment of Pyrophoric Materials in Burial Grounds	Several different operations that used or generated pyrophoric materials were conducted in the 300 Area. The quantity of these materials in 300 Area burial grounds is not well documented but at least 350 and potentially as many as 1500 drums of uranium machining chips have already been discovered. Improved methods for detecting, handling, and treating suspect pyrophoric materials are required. Other pyrophoric materials that are suspected to exist in currently unexcavated burial grounds include zircaloy, magnesium and calcium metals.	Detection of pyrophoric materials in drums and burial grounds	Pyrophoric, i.e. Zircaloy, Mg, Ca	Drums and soil	Applied	Sampling and detection	Not given - "improved methods"
RL-SS20	Improved Methods for Debris Handling and Segregation	A large number of waste burial grounds will be excavated and disposed on site. Improved methods are needed for handling and segregating waste debris that requires further characterization or size reduction prior to disposal.	Segregating waste debris	Waste debris	Burial grounds	Applied	Sampling and detection	Not given - "improved methods"
RL-SS23-S	Detection/Distribution of Contaminants - Chemical Speciation and Complexation in Site-Specific Groundwater	Determine the speciation and complexation of contaminants of interest in an aqueous phase distributed in (1) the vadose zone (pristine and contacted by tank waste liquids) and (2) the aquifer. A secondary need for information on contaminant speciation and complexation supports the development of accelerated analytical methods that can provide data on in-situ chemistry remotely and non- invasively. Some of the constraints include the need for these approaches to be remote, real-time, and either on-line or in-situ methods.	Chemical speciation and complexation	Contaminants of interest	Groundwater	Applied	Sampling and detection	Real-time, in-situ, remote
RL-SS25	Improved, Cost-Effective Methods for Sub-Surface Access to Support Characterization and Remediation	The Hanford site contains large volumes of contaminated vadose zone and aquifer soils. In some areas, these soils are located at depths of 500 ft while access to other soils is restricted by the presence of surface or near surface objects such as buildings or underground tanks. The Hanford geology also is quite varied and ranges from unconsolidated silty sands to gravels and cobbles. Cost effective technologies that allow access to this wide variety of sediments for both characterization and remediation are required.	Sampling under facilities and in deep subsurface	"Contaminants"	Soils and groundwater	Applied	Sampling	"Improved, cost-effective" - deep varied geology

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Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS26	Improved Methods for Determining Distribution of Beta Emitting Contaminants in Subsurface Soils	Contaminants with low Kds and long half-lives like Tc-99 and I-129 tend to represent the greatest health risks in long-term risk assessments for the 200 Area tank farms. Also, strontium contamination in the 100 Area soils and groundwater presents a near term environmental concern due to its close proximity to the Columbia River. Improved, more cost-effective methods of accessing contaminated soils, taking soil samples, and/or measuring the concentration, and/or in-situ monitoring of beta emitting contaminants are required. In situ monitoring is also needed to support long term monitoring associated with long-term stewardship of contaminated soils.	Accessing, sampling, and detecting in Hanford tank farms	Tc-99, I-129, Sr-90	Soils and groundwater	Applied	Sampling and detection	In-situ monitoring, cost-effective
RL-SS31	Provide Advanced Characterization Tools and Methods to Delineate Contaminant Plumes in the Vadose Zone and Relate Plume Distribution to the...	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. To support both site-specific and site-wide assessments that lead to effective remediation, advanced characterization tools and methods are needed to determine nature and extent of contamination and to support field investigations to elucidate key features and processes that control contaminant migration. The primary technical gap associated with delineating contaminant plumes in the vadose zone is insufficient soil, geophysical, geochemical, and hydrological data or methods to resolve subsurface heterogeneities, characterize geohydrologic properties, and map contaminant distributions at different scales in the vadose zone.	Understanding controlling processes of contaminant migration and Delineation of contaminant plumes	"Contaminants"	Soil and groundwater	Applied	Sampling and detection	"advanced tools"
RL-SS35	Technologies to Quantify the Flux of Contaminant from Hanford Groundwater to the Columbia River	Specific issues that need to be addressed to resolve this technical gap include techniques to measure overall contaminant fluxes from the groundwater to the river. The techniques should be designed so that they will not be significantly impacted by the transient effects and measurement artifacts associated with the river stage. They are needed to provide a better estimate of contaminant flux. These techniques should provide representative monitoring data and depth discrete information on contaminant distribution and flux in the aquifer near the river. Additionally, techniques are needed to assess the representativeness and quality of these depth discrete groundwater monitoring methods.	Monitoring techniques to measure contaminants and their flow	"Contaminants"	Groundwater	Applied	Sampling and detection	Depth discrete, representative samples
RL-SS37-S	Monitoring of Contaminants - Chemical Sensor Principles	Establish the physics and chemistry principles that underlie more accurate, more sensitive, and higher resolution measurements of contaminant concentrations in the aqueous and solid (surface) phases. Science needs include obtaining a better understanding of the physics and chemistry that will lead more accurate, more sensitive, and higher resolution measurements. Theory from the fields of electronics, electrical engineering, microfluidics, and chemical physics can be examined for their ability to provide innovative measurement technology.	Innovative measurement technologies	"Contaminants"	Soils and groundwater	Applied	Detection	"more sensitive, higher resolution"
RL-WT017	Long-Term Testing of Surface Barrier	Since the design life of the barrier is 500 to 1,000 years, data will be needed on degradation to better understand the validity of the design life estimate. Concern exists regarding the integrity of barrier designs and the definition of adequate testing to verify barrier performance. This technology need relates to the generation and subsequent regulatory acceptance of adequate design, selection, validation, and monitoring results. Acceptance of these results will allow an environmentally sound, cost-effective, graded design approach for barrier implementation at the Hanford Site. The same Needs statement has been submitted to both the Subsurface Contaminants and Tank Focus Areas.	Monitoring subsurface barrier performance	Implied: all contaminants	Barriers	Applied	Not given	Barrier integrity

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SR00-1024	EAV Disposal Facility Monitoring System for PA Validation and Compliance with DOE Orders	The need is for a vadose zone monitoring system for any new E-Area disposal units (1) to validate the PA (i.e., show that radionuclide migration from the trenches/vaults does not exceed what is predicted by the PA), and (2) to show compliance with the DOE Orders (i.e., that radionuclide leaching from the E-Area disposal units do not exceed the Drinking Water Standards). Conventional groundwater monitoring is not adequate due to the existing contamination in the groundwater and the ´early-warning´ sump monitoring program does not meet the two objectives stated above.	VZ monitoring system to track migration from trenches/vaults in E-Area disposal	radionuclides	Groundwater	Applied	Sampling and detection	Better than conventional monitoring systems
SR00-3017 and SR01-3031 (same)	Non-Invasive Contaminant Characterization Technologies for DNAPL	At SRS, remediation of large plumes contaminated with TCE, PCE, PCBs, and other contaminants are a major challenge. One of the major obstacles lies with determining the source of contamination or contamination ´hot spot´ as well as determining the concentration of contaminants present. Technologies, that are non-invasive and prevent cross-contamination, are being sought to determine the concentration of specific contaminants present at the SRS. These non-invasive technologies should be of high enough resolution to define anomalies (e.g. DNAPL) on a scale of centimeters or inches.	Non-invasive detection methods for subsurface contaminant sources or 'hot spot'	TCE, PCE, PCBs and "other contaminants"	Soil and groundwater	Applied	Detection	Non-invasive, high resolution on order of cms to inches, probably geophysics
SR00-3021	Alternative Sample Collection and Well Installation Technology that Eliminates or Significantly Reduces Aqueous or Non-Aqueous Investigative Derived Waste	At SRS, there is a need for sample collection and well installation technology that eliminates or significantly reduces aqueous and non-aqueous IDW, that controls contaminant migration along well casings, and that is accepted by the regulators. Due to the extensive amount of conventional groundwater monitoring well sampling (about 10,000 samples per year) IDW management is a major task for SRS.	Elimination of IDW thru improved sample collection;& improved well installation to prevent cross contamination	Implied: contamination	Implied: Soil and groundwater	Applied	Sampling	Not given - "improved methods"
SR00-3023	Methods for Locating and Stabilizing Buried Solid Waste	A large number of waste burial grounds were created during fifty years of defense materials production. Documentation and location of materials that were placed in the burial grounds is incomplete. There is a need for non-intrusive or minimally intrusive technology used for determination of burial ground contents and waste boundaries. Methods, capable of meeting regulator acceptance, are also needed for stabilizing the buried waste in place.	Better methods for locating burial ground boundaries and contents	Waste contents	Burial grounds	Applied	Detection	Non-invasive, or minimally invasive
SR00-3027	Long Term Monitoring Technologies	Long term monitoring of closed waste units will become a significant cost in the out-years of the ER program at SRS, due to the regulatory requirement for extended compliance monitoring of waste units. Not only will waste units that have been closed by remedial action require long term monitoring, but so will waste units and groundwater plumes that will have been closed under ´Institutional Control with Monitoring´ and ´Monitored Natural Attenuation (MNA)´ scenarios. Using traditional technology, long term monitoring of waste units will require periodic field sampling and laboratory analysis, which is very expensive and time consuming. Establishment of in-situ remote monitoring technologies allows data to be collected more often and at a substantial cost savings, compared to traditional monitoring techniques.	Improved LTM technologies	Implied: all contaminants	Soils and groundwater	Applied	Sampling and detection	in-situ, remote monitoring, cheaper
SR01-1035	Develop Risk-Based Cost-Benefit Analytical Tool for Long-Term Stewardship	Long-Term Stewardship requires an analytical methodology which can be consistently applied at each of the sites within the DOE Complex. The tool is essential to optimize the risk reduction mandate of the Long-Term Stewardship program in a cost-effective manner.	Alternative analytical methods for LTM	Not given: implied contaminants	Not given: implied soils and groundwater	Applied	Implied: Sampling and detection	Cost effective

APPENDIX E: Applied Needs Statements

Needs Statements Submitted to SCFA - WP1 and WP11

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
SR01-3029	Long Term Monitoring Technologies	Using traditional technology, long term monitoring of waste units will require periodic field sampling and laboratory analysis, which is very expensive and time consuming. Establishment of in-situ remote monitoring technologies allows data to be collected more often and at a substantial cost savings, compared to traditional monitoring techniques.	Improved monitoring technologies for waste units	Contaminants	Not given: implied soils and groundwater	Applied	Sampling and detection	in-situ, remote monitoring, cheaper

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-WT018	Testing of Sand-Gravel Capillary Barrier	Water is the driving force behind releasing contaminants from waste forms and then carrying those contaminants to groundwater. Surface moisture barriers (such as the Hanford barrier) have a design life of a 1,000 years. Yet because of the dry conditions at Hanford, moisture infiltration should be minimized for thousands of years. Unlike a surface barrier (which uses many of the same hydrologic principles), the capillary barrier diverts water away from the object underneath rather than storing the water until evaporation or plant transpiration removes the water. Thus the capillary barrier is expected to have a significantly longer life and be more effective than a surface barrier for moisture diversion. Although the principles of sand-gravel capillary barriers are well established, such barriers (especially the ones the size needed for DOE applications) have not been extensively tested.	Testing capillary barriers for their effectiveness over a 1,000 year period	Moisture - implied contaminants	Soils (cap barriers)	Basic and applied	Sampling and detection	Not given
SR00-1029	Iodine-129 ´Getter´ Materials for Engineered Disposal Systems	Iodine-129 is one of the primary risk drivers for several risk analyses and risk assessments conducted through out the DOE complex. It is also one of the key radionuclides controlling the Waste Acceptance Criteria (WAC) of various disposal sites. One approach to limits its mobility and potential health risk is to employ engineered barriers into the disposal system to sequester the iodine-129. The materials used in these engineered barriers, referred to as getters, must scavenge the iodine-129 under extreme chemical conditions, typically under high pH, high ionic strength conditions.	Identifying and understanding I-129 getters in engineered barriers	1-129	Engineered barriers for disposal sites	Basic and applied	Assume for monitoring: sampling and detection	Chemicals that sequester I-129
SR00-3025	Verification Technologies for In-situ Solidification and Stabilization Closure Actions	In-situ grouting technologies are increasingly being used for waste unit remediation. Methods for establishing the effectiveness of these in-situ techniques are in urgent need of development, both for post installation regulatory acceptance and for long term performance monitoring.	Understanding the effectiveness of in-situ grouting for waste units	"waste"	Grout and soils	Basic and applied	Assume for monitoring: Sampling and detection	Not given
RF-ER15	Improved Statistical Methods for Sampling and Monitoring Plans and Data Analysis	The opportunity exists at the Site to utilize improved statistical methods or tools for improving data analysis, sampling plans, and monitoring plans.	Decision analysis tools, improved statistical methods	Not given	Not given	Basic or Applied	NA	NA
AL-09-01-01-SC-S	Transport of HE and Metals in Fractured Rock and Surface Alluvial Systems	Los Alamos National Laboratory's Technical Area (TA) 16 contains multiple sites contaminated with high concentrations of high explosives (HE), particularly RDX, and metals, particularly barium. TA-16 springs, perched groundwaters, and surface waters are contaminated with HE and barium at levels of regulatory concern. Because HE and metal constituents will probably be left in place, both in the vadose zone and in the alluvial system, a science-based understanding of fate and transport of HE and metals in these media is vital.	Basic understanding of fate and transport	HE (RDX) and Ba	fractured rock and alluvial beds	Basic Research	NA	NA
AL-09-01-05-SC-S	Decision Support Assistance for Remediation and Assessment Design	Predicting groundwater flow, contaminant movement, remediation assessment, or performance assessment of a site is a complex and challenging task. Choosing the correct type of models to use, integrating the issues, and identifying the uncertainties are critical to providing an accurate, useful result. There are many models, approaches, data integration methods, and visualization techniques from which to choose in addressing the questions, from 1-D, 2-D or 3-D; stochastic to deterministic flow and transport equations; geostatistic or deterministic site characterization, etc.	Decision support modeling	"contaminants"	Subsurface	Basic Research	NA	site specific

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
AL-09-01-06-SC-S	Issue of Scale in Flow Prediction and Contaminant Remediation in Porous Media	Flow and transport in the subsurface is influenced by processes and interactions that occur across vastly different length scales. The characteristics of the pore space itself determines where fluids move and where fluids are trapped. Larger scale heterogeneities influence the extent of dispersion, and first arrival times. Traditional methods of modeling and predicting such flow and transport are also subject to issues of scale. Flow characteristics are measured in the laboratory on samples that range from around 2 cm to 30 cm in length. These samples may be taken from field locations that are spaced from tens to hundreds of meters apart. They may be utilized in models to represent grid blocks of meters to hundreds of meters.	Flow and transport modeling - scale up issues	NA	Groundwater	Basic Research	NA	Modeling
AL-09-01-07-SC-S	Integration of Reactive Chemistry into Field-Scale Transport Models	Groundwater contaminant transport models are important and often necessary tools used for the purpose of monitoring, remediating, regulating, and protecting subsurface water resources. Inability to simulate the governing processes efficiently with appropriate model formulation and at appropriate spatial resolution will lead to excessive study cost at best, and at worst, to inadequate design. Development of contaminant transport models over the past decade has progressed along two paths which need to be reconnected. On one path, there has been substantial effort directed toward understanding transport when complex chemical processes are involved (e.g., precipitation/dissolution, oxidation/reduction, surface reactions, aqueous complexation).	Transport modeling - reactive chemistry understanding	"contaminants"	Groundwater	Basic Research	NA	Modeling
AL-09-01-08-SC-S	Differences Between Saturated and Unsaturated Systems	The numerical representation of transport in the unsaturated zone is adapted from transport methods developed for saturated systems. However, as the water content changes, there has been experimental evidence that dispersion and other common parameters used in numerical modeling may have a non-linear relationship as a function of saturation. This indicates that parameters used for saturated modeling may not be scalable to unsaturated systems and that other processes may need to be considered. Defining the correct transport parameters requires a combined effort between laboratory and field experiments, and computational modeling. Intermediate scale laboratory experiments must be used to determine appropriate unsaturated transport parameters that can then be used to improve the parameter.	Modeling saturated and unsaturated zones	Not given	Groundwater	Basic Research	NA	Modeling
AL-09-01-10-SC-S	Physics of Fracture Flow and Transport in the Vadose Zone	There are multiple barriers to our ability to understand and quantify the role of fractures in flow and transport in the vadose zone. One barrier is the complex geometry of the pore space of an individual fracture. Although fractures are most commonly modeled either as parallel plates (fracture network models) or high porosity - high permeability porous media (standard FEM or FDM approach), fractures are, in reality gaps of highly irregular apertures. To further complicate things, the fracture walls typically have heterogeneous mineralogy, part or all of the fracture may be coated with minerals distinct from those found in the matrix, and/or it may be blocked at points by material filling the gap. How such variability of the fracture affects flow and transport in the fracture itself.	Modeling in fractured rock - flow and transport	Not given	Groundwater	Basic Research	NA	Modeling
AL-09-01-11-SC-S	Water Fluxes and Solute Transport in Arid and Semiarid Environments	The hydrology of arid and semiarid regions of the American West and worldwide is becoming increasingly important both for water resources and environmental protection issues. As the sun-belt population soars, water resource demands are increasing, and more and more urban areas are seeking external sources of groundwater, often from desert basins. Both regulatory drivers and common sense require quantification of the long-term sustainable yield of these basins before reasonable political decisions on the appropriateness of such water transfers can be made. This quantification, in turn, requires a scientific understanding of arid-zone recharge processes. At the same time, society is turning to arid regions for disposal of long-lived wastes, both radioactive and chemical.	Groundwater recharge or gw resources	Not given	Groundwater	Basic Research	NA	Modeling

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
AL-09-01-12-SC-S	Groundwater-Surface Water Interactions	As water resources become of increasing concern, both in the U.S. and world-wide, more and more communities are turning to conjunctive use of groundwater and surface water to meet their needs. Any rational conjunctive use management requires an understanding of the effects of the interaction between groundwater and surface water, i.e., what effect does groundwater pumping have on streamflow, and what affect do surface water diversion have on groundwater recharge? Groundwater-surface water interactions has implications for water quality issues as well as water supply issues. In arid and semi-arid environments, infiltration is often the major source of uncertainty in simulations of contaminant transport in the vadose zone (e.g., Hanford, Yucca Mountain, Los Alamos).	Groundwater resources, groundwater interaction with streams	Not given	Groundwater	Basic Research	NA	Modeling
AL-09-01-14-SC-S	Vadose Zone Flux Rates	Waste and contamination at many DOE sites is located in the unsaturated or vadose zone. A sensitive parameter is the flux of water moving through the vadose zone in order to estimate potential contaminant movement to the saturated zone. The highly variable input to the system from the climate, land use changes, ecological succession, and soil forming processes introduce large uncertainties in this estimate. This is particularly true for radionuclides where long-term flux estimates (periods >100 years) are needed. Performance assessment maintenance programs at operational waste sites and environmental restoration remediation decisions have a need for understanding these flux rates for the groundwater pathway component.	Modeling groundwater fluxes through vadose zone	"contaminants"	Groundwater	Basic Research	NA	Modeling
AL-09-01-16-Risk-S	Extrapolation Bias and Uncertainty from using Biomarkers and Numerical Models to Predict Real Ecological Effects	Using models (biological or numerical) to extrapolate from laboratory and literature data to ecological risk at a specific site is necessary to control costs of risk assessment and management. However without field tests of reliability, risk assessment models are vulnerable to technical challenges by stakeholders. These challenges may slow or even reverse decisions about the existence of ecological risks. Given our best attempts to model the relevant toxicological, biological, and ecological processes, how confident can we be in predictions about ecological risk at different sites, for different populations, and for different ecosystems without field tests of their reliability?	Field testing models, verifying reliability	Not given	Not given	Basic Research	NA	Modeling
CH-SS02-00	Demonstrate Effectiveness of Phytoremediation in the Removal of Tritium from Groundwater	11/15/2000: Title of Need changed to "Continuation of Expanded Monitoring Activities for Tritium and VOC Fate at the 317/319 Area at ANL-E" The 317/319 areas at ANL are contaminated with tritium and VOCs. A phytoremediation system was installed in 1999 and will be reaching full treatment potential in FY2003. There is a need to continue monitoring-related research to understand the fate of the contaminants in the plant system in times shorter than achievable with compliance-related monitoring.	Phytoremediation - understanding uptake	Tritium and VOCs	Groundwater	Basic Research	Implied - detection	In plants
ID-6.1.24	Understanding the Migration of VOCs Around an ISV Melt	An understanding or model of the gas phase transport of contaminants in the fractured media below and adjacent to the INEEL SDA at RWMC is needed to fully determine the risk and potential of contaminant migration . This analysis is required to provide a representative model of the SDA as it exists now, and determine the effects of an ISV treatment on the gas phase transport of the contaminants.	Gas phase transport of contaminants during ISV	"contaminants"	Fractured media	Basic Research	NA	Modeling
ID-S.1.09	Characterization of Scale and Spatial Heterogeneity and Preferential Flow	Currently there is a lack of understanding of how to scale for comparison the solute transport phenomena of small discrete laboratory flow analyses to much larger chaotic flow zones such as the vadose. Therefore, a method or model is needed that will address the effects of space, time, and scale on the mass transport of the solute through differing media.	Modeling solute transport: scale up issues from lab to field	Not given	Soil and groundwater	Basic Research	NA	NA

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ID-S.1.11	Modeling of Flow and Transport in the Vadose Zone	Noted deficiencies have been found in the current model and need to be addressed to provide a better representative model of flow and transport in the vadose zone.	Flow and transport of vadose zone; modeling deficiencies	Not given	Soil and groundwater	Basic Research	NA	NA
ID-S.1.12	Understanding the Behavior of Waste Forms and their Near-Field Transport	Research or studies need to be performed on the vicinity surrounding waste containers to better understand the chemical interactions and hydrology that occur due to this presence.	Understand chemical interactions/waste and environment	Not given	Soil and groundwater	Basic Research	NA	NA
ID-S.1.13	Longevity of Engineered Barriers	Arid regions such as the INEEL may be able to apply alternative, less expensive surface covers, instead of covers developed by the EPA that focus on water filteration by simply understanding barrier design and filteration effects of different types of covers.	Better understanding of cap performance of engineered barriers	Not given - implied contaminants	Soils and groundwater	Basic research	NA	NA
ID-S.1.14	Transport of Contaminants in the Vapor Phase	Vapor phase processes can cause a substantial flux of volatile organic chemicals and radionuclides through the subsurface environment, and are often the dominant migration mechanism in arid environments such as the INEEL's. Despite the importance of vapor phase transport, only limited studies have been conducted to characterize vapor transport processes at the INEEL.	Transport of vapor phase contaminants in subsurface	"Contaminants"	Vapor	Basic Research	NA	NA
ID-S.1.15	Physics of Flow in the Vadose Zone	Current models of flow inadequately predicted the presence of actinides in groundwater. An understanding of why these models errored to predict this presence is needed to predict future migrations of contaminants and to ensure DOE-ID maintains credibility with its stakeholders.	Flow and transport in vadose zone	Actinides	Groundwater	Basic Research	NA	NA
ID-S.1.16	Quantifying Uncertainty in Risk Calculations	Risk calculations used to make remedial action decisions need to better quantify uncertainty.	Uncertainty in risk calculations	Not given	Not given	Basic Research	NA	NA
ID-S.1.25	Accurate Prediction of Impacts from Catastrophic Flood Events	Facilities such as the Environmental Restoration Disposal Facility at Hanford, the CERCLA Disposal Facility at the INEEL, the potentially unmitigated portions of the INEEL's subsurface disposal area, entombed reactor facilities, entombed high-level waste management units, and many other proposed end state facilities are, in theory, designed to state of the art criteria. Our ability to design intrinsically safe and stable structures for the purpose of containing contaminated materials has not been matched an ability to predict the occurrence, magnitude and "behavior" of natural phenomena such as flood events, or flood-like events such as levee failures and dam breakage. Catastrophic flood events such as the postulated Mackay Dam break and their impact on INEEL structures are not accurately predicted using standard one-dimensional codes such as HEC-1, HEC-2 or the National Weather Services DAMBRK model.	Better understanding of impacts of catastrophic events on Disposal facilities	Not given - implied contaminants	Not given - implied soils and groundwater	Basic research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
ID-S.1.40	Monitoring Impacts of changes on Modeling Requirements and Toxicity Data	All cleanup and closure decisions are made with computational models the results of which demonstrate compliance with existing regulations. The accuracy of these model results are highly dependent upon not only the conceptual model of how contaminants will move through the environment but also upon select modeling assumptions, parameter values and contaminant toxicity values. There are four parts to this need. The first is to identify those key modeling assumptions, parameter values and toxicity values that greatly influence the results. The second part is to establish a mechanism that ensures that every few years the conceptual model, modeling assumptions and parameter values are reverified. That no new models that are more appropriate are not available and that the toxicity values for the contaminants of concern have not changed. The third part is if there are changes then there needs to be a mechanism in place to rerun the calculations and ensure that the site still poses no unacceptable risk to human health and the environment. If the site doesn't pass then a mechanism to alert the proper agency to take appropriate ac	Modeling issues	Not given	All media implied	Basic Research	NA	NA
OK01-28	Increased Understanding of Chlorinated Volatile Organic Compound (VOC) Plumes to Ensure Remediation	An increased understanding of VOC plume behavior in various hydrogeologic settings is needed to support remediation strategy evaluations. The key goal is to optimize our characterization and remediation efforts. A broader understanding of the behavior of VOC plumes, in general, is needed in order to identify patterns that can be used to place bounds on the uncertainties for the behavior of plumes. This need is similar to OK99-22 LLNL Site 300 need to understand plume behavior to chose remediation strategies.	Understanding of VOC plume behavior	Chlorinated VOCs	Soils and groundwater	Basic Research	Not given	NA
OK99-22	Sufficient Understanding of Chlorinated Volatile Organic Compound (CVOC) Plumes (in general) to	An increased understanding of CVOC plume behavior in various hydrogeologic settings is needed to support remediation strategy decisionmaking. The key goal is to optimize our characterization and remediation efforts while addressing regulatory concerns adequately. A broader understanding of the behavior of CVOC plumes, in general, is needed in order to identify patterns that can be used to place bounds on the uncertainties for the behavior of specific plumes.	Better understanding of chlorinated VOC plume behavior	Chlorinated VOCs	Soil and groundwater	Basic Research	NA	NA
RL-SS24-S	Detection/Distribution of Contaminants - Chemical Binding on Site-Specific Mineral Surfaces	For Hanford site conditions, determine the reactions that will affect the binding of contaminants in solution on secondary mineral surfaces, and on primary phases, if relevant.	Identification of chemical binding on mineral surfaces	"Contaminants"	Soils	Basic Research	NA	NA
RL-SS25-S	Detection/Distribution of Contaminants - Chemical Form and Mobility of Dense, Non-Aqueous Phase	For Hanford vadose zone and aquifer, determine the chemical form and mobility of dense, non-aqueous phase liquids such as chlorinated solvents in contact with (1) pore water and groundwater, (2) secondary minerals.	Understanding of chemical form and mobility of DNAPLs	DNAPLs	Pore water, groundwater, minerals	Basic Research	NA	NA
RL-SS26-S	Transport of Contaminants - Reaction Rates for Key Contaminant Species and Complexes in Site-Specific	For Hanford site conditions, determine the reaction rates and the key reaction steps that control the speed with which a contaminant changes chemical form (e.g. speciation, complexation) and/or interacts with the surfaces of secondary minerals. For waste streams associated with implemented restoration technologies, establish the important reactions and associated rates of contaminant transformation.	Identifying and understanding chemical transformation of contaminants on soils	"Contaminants"	Soils/minerals	Basic Research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS27	Use of Field Data from Representative Sites to Elucidate Controlling Features and Processes for Contaminant Distribution	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. Currently, information on contaminant distribution, physical association, and chemical form in the vadose zone beneath waste sites of different source terms, ages, and water flow histories (e.g., cribs, tanks, trenches, spills, etc.) is not adequate to forecast whether future breakthrough to groundwater will occur. Hence, there is a need to investigate select field sites that are representative of major Hanford waste and disposal scenarios to develop rigorous conceptual models of governing processes for use in remediation and closure characterization assessment and performance validation.	Understanding controlling chemical/physical processes for contaminant distribution and transport in VZ, Modeling	"Contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS27-S	Transport of Contaminants - Rate of Coupled Abiotic and Biogeochemical Reactions Involving	For Hanford site conditions, determine the effect on contaminant form (e.g. speciation/complexation/reaction) of coupling important abiotic and biogeochemical reactions for which independent rates of reaction are known.	Identifying and understanding chemical transformation and rates of rxns of contaminants on soils	"Contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS28	Understand, Quantify and Develop Descriptions of Reactions and Interactions between Contaminants of Concern and Vadose Zone Sediments	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. The primary technical gaps associated with reactions and interactions between wastes and vadose zone sediments are that the chemical and biologic reactions and colloidal transport processes responsible for contaminant retardation, immobilization, and mobilization are insufficiently understood or lack data on key parameters to allow for defensible predictions of their in-ground rates, extent, magnitude, and effect. This information is important to resolve important Hanford-specific geochemical questions for key contaminants.	Identifying and understanding chemical transformation and rxns that influence transport in VZ	"Contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS28-S	Transport of Contaminants - Rates of Colloid Formation and Colloidal Transport of Contaminants in	For Hanford site conditions, determine what secondary minerals form as colloids in groundwater, determine the importance of biosorption, and establish the nature of the chemical interactions between contaminants of interest and the surfaces of inorganic and organic colloids.	Understanding chemical transformation with emphasis on colloidal formation and transport	"Contaminants"	Groundwater	Basic Research	NA	NA
RL-SS29	Develop Descriptions of Contaminant Flow and Transport in the Vadose Zone	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. Improvement in modeling of vadose zone transport requires developing models which can capture the important complexities. This development will take the form of enhancing existing codes to represent additional processes, running them with finer grids and time spacings, and simulating some of the heterogeneities and episodicities. Partial coupling of physical and chemical processes may also be needed.	Improving transport modeling in VZ	"Contaminants"	Groundwater	Basic Research	NA	NA
RL-SS29-S	Transport of Contaminants - Effect of Subsurface Heterogeneities on Chemical Reaction and	Determine how the physical and chemical properties of the specific Hanford formations affect the transport of chemical solutes and colloids.	Understanding chemical transport with emphasis on Hanford soils and chemical rxns	"Contaminants"	Groundwater	Basic Research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS30	Understand and Quantify Water Movement in the Vadose Zone Using Uncontaminated Field Sites	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. The rate of movement of contaminants from buried waste through the vadose zone to groundwater is presently not well documented for Hanford Site conditions. The primary technical gap associated with transport in the vadose zone is an insufficient understanding of uncertainties in source terms, geohydrologic properties, and chemical interactions that combine to make current modeling of contaminant transport in the Hanford vadose zone questionable.	Improving transport modeling in VZ with emphasis on uncertainties	"Contaminants"	Groundwater	Basic Research	NA	NA
RL-SS31-S	Remediation - Mathematical Formulations of Chemical Reaction/Material Transport	For site conditions, contaminant chemistry and reactivity, and hydraulic properties at Hanford, formulate the chemistry and physics needed to describe the dispersal and longevity of subsurface contaminant plumes.	Understanding transport of contaminant plumes	"Contaminants"	Soil and groundwater	Basic Research	NA	NA
RL-SS32	Understand and Quantify the Relationship Between Contaminant Sources, Vadose Zone Plume Properties and Groundwater Plume Properties at Hydrologic...	Information about vertical distribution of the groundwater plume near the source is also important to help infer how contaminants move through the vadose zone. For example, deeply distributed carbon tetrachloride in the aquifer beneath Plutonium Finishing Plant disposal sites implies drainage of a DNAPL through the vadose zone that "settles" in the aquifer. Contaminant concentrations that are highest in the capillary fringe, or at the very top of the aquifer, would imply unsaturated flow through the vadose zone and a low pore fluid density.	Understanding transport of contaminant plumes with emphasis on hydraulic processes	"Contaminants"	Groundwater	Basic Research	NA	NA
RL-SS32-S	Remediation - Reactivity of Organics in the Hanford Subsurface	For naturally occurring organic matter and synthetic organic compounds in the Hanford subsurface, determine the rates of degradation reactions that supply energy to subsurface biological consortia that participate in dechlorination of halogenated solvents.	Understanding dechlorination reactions in NA	Halogenated solvents	Soils and groundwater	Basic Research	NA	NA
RL-SS33	Techniques to Delineate Groundwater Plumes in Three Dimensions and Define a Scientific Basis for Addressing Scaling Issues in Hanford Groundwater	This need focuses on the extension of our current knowledge of groundwater characteristics to support side-wide assessments. The structure and development of the regional groundwater plumes is critical to estimating inventory of contaminants in groundwater for site-wide assessments. This plume structure also provides information about controlling hydrogeology and is critical to calibrating and documenting the quality/performance of numerical models. In addition, hydrogeological characterization at multiple scales is needed to understand and predict the flows and transport at Hanford.	Understanding flow and transport at all scales and predicting total volume of contaminant plumes	"Contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS33-S	Remediation - Interaction of Remedial Processes with Hanford Subsurface	For technologies implemented under Hanford conditions, determine the interactions and reactions between materials used in the remedial process, and dissolved, adsorbed, and/or precipitated contaminants associated with native mineral surfaces.	Understanding contaminant/soil interactions on mineral surfaces	"Contaminants"	Soils and groundwater	Basic Research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS34	Understand, Quantify and Develop Descriptions of Biogeochemical Reactions and Interactions Between Contaminants of Concern and Aquifer Sediments...	This need focuses on the reactions and interactions between contaminants and aquifer sediments. The primary technical gap is an insufficient understanding of these processes at Hanford in terms of quantifying and parameterizing the processes for use in reactive transport modeling and to determine appropriate conceptual models. Biogeochemical reactions may result in either enhanced contaminant mobility, degradation (natural attenuation), or fixation in the unconfined aquifer. An understanding of these fundamental processes is needed to predict the long-term behavior of contaminants as they enter the unconfined aquifer and during transport along the groundwater flow path to the river.	Understanding contaminant transport relative to biogeochemical processes	"Contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS34-S	Remediation - Selectivity for Contaminants in the Hanford Subsurface	For Hanford site conditions, determine those chemical reactions that can select among contaminants and be used to separate contaminants from contaminated groundwaters and soils.	Remediation need - chemical rxns that separate contaminants from GW and Soil	"Contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS36	Provide Means to Integrate Regional-Scale Phenomena into Assessments of Contaminant Transport and Impacts within the Columbia River	The primary gap for this need is the lack of a quantitative understanding of the regional (watershed) factors that influence the distribution, transport, and chemical form of contaminants from Hanford on the Columbia River. Key factors include river flow parameters; sediment movement and sedimentation; water hardness, pH, water temperature; the distribution of gravel, cobble, and silt/clay sediments within the Hanford Reach and downstream; and the redox status and acid-volatile sulfide contents of softbottom sediments in these areas. Although these factors are known to be important in determining contaminant movement, there is little capability to predict either (a) the responses of these factors to regional conditions or (b) the combined effects of these factors on contaminants.	Understanding contaminant transport, distribution and chemical form	"Contaminants"	Soils and groundwater	Basic research	NA	NA
RL-SS37	Provide Methodology to Relate Information Derived from Sitewide-Scale Groundwater Flow Modeling to the Various Scales Associated with Assessing Impact	The technical gap associated with this need involves the means by which contaminant transport information derived from groundwater flow models (see RL-SS35) can be used when conducting impact assessments for various elements of the river system. The problem involves relating the spatial and temporal scales associated with a Pasco Basin groundwater transport model, to the scales associated with assessing impacts to sensitive habitat and individual receptors. New methods are needed to establish credible estimates for contaminant characteristics at exposure sites in the river, when using the output from groundwater transport models.	Correlation of transport models of regional scale modeling to river impact assessments	"Contaminants"	Soils and groundwater	Basic research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS38	Understand, Quantify and Develop Descriptions of Transport and Transformation of Groundwater-Derived Contaminants of Concern in the River	The primary technical gap associated with reactions and interactions between contaminants and sediments in the river and bank-storage region involves insufficient understanding of these processes at Hanford in terms of quantifying and parameterizing the processes for use in the development and application fate and transport. An understanding of these fundamental processes is needed to predict the fate and transport of contaminants into and through the river.	Understanding contaminant fate and transport with emphasis on interactions between sediments and contaminants	"Contaminants"	Groundwater	Basic Research	NA	NA
RL-SS39	Understand and Provide Means to Quantify the Impacts of River Contamination on Receptors	The primary technical gap associated with the impacts of river contamination on receptors is that there is an insufficient understanding of the human, ecological, cultural and socio-economic impacts of contaminants that reach the river and the relationship between contaminants entering the river and behavioral impacts on culture and socio-economics. Currently, standard impact assessment practice involves comparing estimated exposures of individual organisms to a lowest observed effects level toxicological benchmarks, such as behavioral change or tissue-level alterations.	Understanding and quantifying all impacts (including cultural and socio-economic) of contaminant transported to river and environment	"Contaminants"	River	Basic Research	NA	NA
RL-SS40	Provide a Method to Develop Mass Balance (i.e., Holistic) Inventory Estimates	Currently, there is not a full inventory data set for all of the contaminants of interest for all of the waste sites of interest at Hanford. These data are needed as input to the SAC which is a suite of tools and data that will be used to assess the cumulative effects of Hanford operations and remediation on the Columbia River and river supported life. Based on scoping studies currently underway within the SAC, key radionuclide and chemical contaminants of most concern for assessing cumulative impacts will be identified. From previous experience, we know there will be gaps in inventory data for many of these contaminants, and that these gaps will contribute significantly to uncertainty in the final assessment.	More data needed on key radionuclide and contaminants for mass balance assessments	"Radionuclides and contaminants"	Soils and groundwater	Basic Research	NA	NA
RL-SS42	Provide Method for More Accurate Estimates of Waste Constituent Release Rates and Modes from Waste	The primary technical gap is the need for models to describe release rates from all waste that will reside at the Hanford Site in the post-closure period. Thus, models and supporting data are needed for radionuclide and chemical releases from solid waste burial grounds, past tank leaks, future tank losses, tank residuals, proposed immobilized low-activity waste, past-practice liquid discharge sites, canyon buildings, PUREX tunnels, the PFP building, and the graphite cores of production reactors. These modeling results provide temporal and spatial information for system assessments.	Better modeling describing rad and chemical waste release rates from multiple Hanford sources	"Radionuclides and contaminants"	Implied: All media	Basic Research	NA	NA
RL-SS43	Improvements to Ecological Risk Assessments and Analysis of Population-level Impacts	Techniques, technologies, and information that reduce uncertainty in current risk assessments and more-directly address applicable ecological risk guidelines and regulations are needed to address ecological risks posed by contaminants at Hanford. Current techniques and information are insufficient to predict accurately individual exposures to contaminants, especially where food chains and nutrient analogues are involved, and the effects from this exposure. Thus, conservative assumptions are required that increase uncertainty in the assessment results.	Better understanding of uncertainties derived for risk assessments, better estimates	"Contaminants"	Implied: All media	Basic Research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
RL-SS44	Improvements to Human Health Risk Assessments	Improved techniques and information that reduces analysis uncertainty are needed for human health risk assessments. This will increase the scientific defensibility, realism of the analysis and comprehensiveness of the assessment. Improvements are needed in all four basic steps of human health risk assessments, hazard identification, exposure assessment, dose-response assessment, and risk characterization (NRC 1983).	Better understanding of uncertainties derived for risk assessments	"Contaminants"	Implied: All media	Basic Research	NA	NA
RL-SS45	Establishing Technical Basis for Socio-Economic Risk Assessments	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. This need outlines improved techniques and information required for the inclusion of economic risk to the decision-making process. Economic impacts can occur directly from changes in human and ecological health due to exposure to contamination, or impacts can occur indirectly due to "ripple effects" from the former impacts. Economic impacts do not result until risks are perceived. The first step is to determine at what point does the level of environmental risk begin to influence the behavior of people such as consumers, producers, recreational fisherman, and sailboarders, for example.	Better understanding of socio-economic risks associated with health risk assessments	"Contaminants"	Implied: All media	Basic Research	NA	NA
RL-SS46	Modeling Risk Knowledge	This need addresses specific technical gaps identified in the scope of the GW/VZ Integration Project at the Hanford Site and is written as an "integrated" need. This need recognizes that knowledge is socially constructed. Successor socio-cultural studies will lay the epistemological foundation for understanding how the various affected cultural communities organize knowledge relative to risk. There is a need to take those findings and produce an integrated risk perception model. The model will be essential for finding common intellectual ground, which is essential for building partnerships in dealing with Hanford Site waste.	Better understanding of socio-cultural risks associated with health risk assessments	"Contaminants"	Implied: All media	Basic Research	NA	NA
RL-WT029	Data and Tools for Performance Assessments	Performance assessments must be developed for all disposal actions, and the models that are used for these assessments require a defensible basis for the movement of water. Most databases describe recharge and distribution of water for non-arid conditions. The arid conditions at Hanford are not accurately represented by the existing data. This need is comprised of two elements: 1) Recharge water is the primary means for dissolution and release of contaminants from the buried waste and transport of those contaminants to the groundwater. Estimation of these rates is difficult under arid conditions because the rates are very low. In addition, there are significant questions about the adequacy of the estimated recharge rates given the heterogeneity of the environmental processes, the effect of facility features, the uncertainty of climate, and the influence of humans. Furthermore, no attempt has been made to quantify the distribution of recharge rates to enable sounder estimates of the mean and range of rates to be expected during the time of compliance of the facility.	Better estimates of recharge rates	Not given	Groundwater	Basic Research	NA	NA
RL-WT035-S	Moisture Flow and Contaminant Transport in Arid Conditions	To understand the movement of contaminants through zones of low moisture for use in risk assessments. Most of the work concerning moisture flow and contaminant transport has been done at sites important for agriculture, i.e., sites having moisture contents near saturation. Thus, the theories and equations for moisture flow and contaminant transport are modifications of theories and equations for fully saturated environments. In such an environment, it is movement through the pore spaces between soil particles that is dominant. Under very dry conditions, the interactions with the soil particles will become more important. Tested theories and equations are needed for use in performance assessment in order to predict moisture movement and contaminant transport.	Better understand and estimates of moisture flow and contaminant transport in arid regions	"Contaminants"	Groundwater/moisture	Basic Research	NA	NA

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RL-WT043-S	Effect of Human and Natural Influences on Long-Term Water Distribution	Water passing through the soil surface to the waste disposal facility provides both the agent to release the contaminants from the waste form as well as the medium to transport the contaminants to the groundwater. The amount of water applied to the surface over the next thousands of years will vary because of climate changes and because of human-initiated events. Efforts are needed to 1) consider long-term land and water use at DOE sites by future generations; 2) consider natural phenomena such as near-term climate change (which is forecast to impact society in the next 100 years) or long-term climate change as we transition into the next ice age; and 3) incorporate those uses and impacts into modeling efforts to predict the transport of contaminants.	Better understanding of recharge rates influenced by climate change	"Contaminants"	Groundwater/moisture	Basic Research	NA	NA
RL-WT045-S	Vadose Zone Flow Simulation Tool Under Arid Conditions	To predict the movement of contaminants from the disposal of waste, a wide variety of chemical and physical phenomena must be modeled over large spatial scales and over time periods lasting thousands of years. For the release of contaminants from immobilized low-level tank waste, the physical condition and surrounding water chemistry for thousands of canisters must be modeled, where the physical and chemical environment vary with time and position in the disposal vault. For the modeling of flow into disposal facilities or around tanks in large tank farms, detailed three-dimensional geometric models must be used transient moisture fronts and steep concentration gradients must be analyzed. Finally, because of the low moisture content of Hanford soils and the significant thickness of the vadose zone, simulations over many thousands of years are required, even for the most mobile contaminants. Develop a computer code using modern computer science techniques that combines time and spatially-dependent geochemical modeling with transient moisture flow and contaminant transport and which allows the determination on the results of modeling and da	Better understanding of flow in VZ around disposal facilities and subsurface structures	"Contaminants"	Groundwater/moisture	Basic Research	NA	NA
RL-WT053-S	Contaminant Mobility Beneath Tank Farms	Quantify and understand the evolution of the present distribution of contaminants, both radioactive and nonradioactive (cesium-137, Pu, Tc-99, Sr-90, Cr, and nitrate), beneath the tank farms and to evaluate their potential mobility under all "leave or retrieve" options. The current understanding of the mobility of contaminants from single-shell tank leaks and major soil column transuranic disposal sites is inadequate to fully support cleanup, closure, or performance assessment-related decisions. Without knowledge about the distribution of contaminants beneath the tank farms, and without the ability in hand to predict contaminant movement, it will be impossible to assure the public that the DOE can predict: the impact of leaks during sluicing and the impact of leaving the tanks in place.	Basic understanding of contaminant mobility under tank farms and resulting distribution	Cs-137, Pu, Tc-99, Sr-90, Cr and nitrate	Soil and groundwater	Basic Research	NA	NA
SR00-1026	Reduce the Conservatism and Technical Uncertainty Associated with the Use of Literature Coefficients (Kd) to Describe Radionuclide Sorption to Sediment	Performance assessment models have traditionally employed a single linear partition coefficient (Kd) to set allowable nuclide inventories for solid waste disposal facilities. These Kd values generally do not do a good job of describing contaminant partitioning with changing chemical conditions or soil character. There is, therefore, a need to develop alternative concepts for describing contaminant partitioning in the subsurface systems beneath radioactive waste disposal facilities. These new concepts need to account for the impacts changing chemical conditions and the site-specific character of the soils and groundwater at the facility on nuclide partitioning.	Identifying alternative contaminant partition predictors (rather than Kds)	Implied: radionuclides	Soils and groundwater	Basic Research	NA	NA

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SR00-1030	Model Degradation in Cement Based Wasteform (e.g., Saltstone) and Concrete Vault Degradation and Collapse	The need is to develop and implement a modeling methodology for degradation of Saltstone, a cement-based wasteform, and the concrete vaults into which it is emplaced over time periods of thousands of years. This will be incorporated into the next revision of the Saltstone Disposal Facility Performance Assessment. The currently applicable Performance Assessment only considers end members in the degradation scenarios, i.e., the vault and wasteform are analyzed as being either intact or completely degraded.	Develop modeling methodology for degradation of cement-based wasteform and concrete vaults over thousands of years	Cement-based waste forms	Saltstone and concrete	Basic Research	NA	NA
SR00-3026	Innovative Remediation Strategies and Technologies to Support Monitored Natural Attenuation	The concepts of natural remediation mechanisms and rates need to be investigated further in order to better predict plume behavior. These concepts potentially in conjunction with passive remediation technologies need to be developed to a deployable status for very large areas of contamination. General categories of contamination include VOC contaminated groundwater, tritium contaminated groundwater and metals/ radionuclide contaminated soils and groundwater plumes.	Basic understanding of plume behavior during MNA - mechanisms and rates	VOC, tritium, metals and rads	Soils and groundwater	Basic Research	NA	NA
SR01-1034	Determine the Fate of Pu in the +6 Oxidation State in the Near-Surface Disposal Environment	New plutonium chemistry developed by Haschke et al. (Haschke, J.M., T.H. Allen, and L.A. Morales, Reaction of Plutonium Dioxide with Water: Formation and Properties of PuO2+x, Science, Volume 287, pp.# 285-287, 1/14 (2000)) suggest that plutonium dioxide, once thought to be the thermodynamically stable form, reacts with water to form plutonium in the +6 oxidation state. Pu in the +6 oxidation state is sorbed much less strongly than Pu in the +4 oxidation state. Thus, unless environmental factors would reduce the Pu+6 to Pu+4, performance assessments and composite analyses of low-level waste disposal facilities may not bound the actual performance. Therefore, there is a need to develop detailed information on plutonium chemistry in the LLW disposal environment.	Better understanding of Pu chemistry in LLW disposal sites	Pu	Soils and groundwater	Basic Research	NA	NA
SR01-3026 and SR01-3028 (same)	Innovative Technologies to Support Natural Remediation	The concepts of natural remediation mechanisms and rates need to be investigated further in order to better predict plume behavior. These concepts potentially in conjunction with passive remediation technologies need to be developed to a deployable status for very large areas of contamination. General categories of contamination include VOC contaminated groundwater, tritium contaminated groundwater and metals/ radionuclide contaminated soils and groundwater plumes.	Better understanding of contaminant plume behavior during NA remediation	VOC, tritium, metals and rads	Soils and groundwater	Basic Research	NA	NA
RL-WT044-S	Distribution of Recharge Rates	Fundamental data to improve confidence in the estimation of recharge rates as a function of time and space for use in impact assessments under realistic conditions. The rate at which moisture exits the surface root zone of soil and enters into the subsurface is often the major parameter determining the rate at which contaminants enter groundwater, especially in dry climates. The recharge rate is known to depend upon many parameters. However, this dependence is usually determined for idealized conditions and for small spatial and temporal extents. For large sites where impact calculations must extent beyond thousands of years, such simple descriptions are inadequate to convince the technical community, the regulators, and the stakeholders that impacts can be adequately estimated.	Better understanding of recharge rates influenced by climate change	"Contaminants"	Soil and groundwater	Basic Research	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
AL-09-01-09-SC-S	Quantifying Uncertainty in Predictions of Remediation Performance	A barrier to wider use of many in situ remediation technologies is that results are often variable and difficult to predict. An incomplete understanding of the effects of variable site characteristics and the lack of adequate tools to predict and measure success, has made the design, control and validation of many of these technologies more empirical than desired. In large part, it is the uncertainty associated with newer, more innovative options that has driven site owners and regulators to choose more costly and less effective treatment options. Practical tools are needed that allow site owners and providers of remediation services to solve problems in site specific design, implementation and performance assessment of various remediation strategies.	Quantifying uncertainty of remediation performance - very general "remediation technologies"	Not given	Not given: implied soils and groundwater	Basic research - studies on performance of remediation technologies	NA	NA
AL-09-01-15-SC-S	Separation of Metals and Radionuclides from Uncontaminated Soils; Transport of Metals and	Los Alamos National Laboratory's Firing Sites contain soils contaminated with high concentrations of metals, and radionuclides, particularly depleted uranium. Because metal and radionuclide constituents will remain after cleanup, both at the surface and potentially in the alluvial system, a science-based understanding of separations of these materials, and fate and transport of theses constituents in these media is vital.	1) Separation problem and 2) Transport modeling	metals and rads	Soils	Basic Research and Applied	NA	2) Modeling
ID-S.1.26	Determine impacts to and by biota at the INEEL	Impacts of operations and remedial actions to the biota at the Site need to be assessed in a rapid manner. Additionally, caps/barriers/etc. need to be protected from plant and animal intrusion (e.g. burrowing rodents, roots, etc.). A need exists to quickly detect, assess, and mitigate the impacts to the biota and intrusion of biota to structures.	Understanding impact of biota on remediated sites and remaining barriers and structures	Not given - implied contaminants	Implied soils	Basic research and applied	Implied: Sampling and detection	Not given
NV11	Long-Term Management of Void Space, Containers, and Cover Subsidence of Disposed Waste (former NV11-0001-08)	Methods need to be developed to better predict the dynamics of collapse of void space, container/waste form degradation, and subsidence of closure materials in waste disposal cells. An increased understanding on the dynamics of subsidence would lead to more realistic estimates of the magnitude and timing of subsidence. Moreover, if subsidence can be accelerated during the operational period, or the period of institutional control (100 to 250 years), the effect on closure covers over waste cells can be more readily mitigated through periodic maintenance.	Understanding impact of subsidence on disposal cell performance	Contaminants	Disposal cell covers - soils	Basic research and applied	Sampling and detection	Monitoring void spaces in caps and soils under waste disposal cells
RL-SS35-S	Monitoring of Contaminants - Use of Chemical Surrogates for Contaminants	To assess potential migration of difficult-to-measure contaminants in the Hanford subsurface, select relevant chemical analogues (similar group, charge, ionic size, physical state) to contaminant of interest that can be measured by existing measurement technologies.	Identifying contaminant surrogates and measurement techniques for surrogates	"Contaminants"	Implied: All media	Basic research and applied	Detection for applied need	Appropriate surrogate chemicals to study contaminants
RL-SS36-S	Monitoring of Contaminants - Chemical Indicators of Remedial Technology Processes	For Hanford site-specific conditions, identify the species that form during a remedial technology process (chemical, physical, and/or biological) and are indicative of key reactions that make the technology work. Determine concentrations of key species that represent the endpoint(s) of the technology process.	Understanding the chemical species at the endpoint and during a remedial process	"Contaminants"	Not given - implied soils and groundwater	Basic Research and Applied	Sampling and detection	Not given
OH-F155	Long-Term Data/Image Repository	Need a System to store and retrieve data and images at the Fernald Site as part of the post closure stewardship program. The system should be capable of being accessed via the Internet and being updated as technological advances are made. The data and images would be part of the regulatory requirements of the site and the long term monitoring of the site following closure.	Data and images management system for LTM - store and retrieve same	NA	NA	Information system	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
OH-F161	Standardized Document Management/Characterization System	There is a need for a standardized system throughout the DOE complex for the management of documents and waste characterization data. The current system in use is site-dependent. Data is kept in systems that may not be compatible. The systems do not record data in a manner that is exchangeable between sites today or in the future. (May tie to Button technology.)	Management system for documents and waste data	NA	NA	Information system	NA	NA
ID-4.2.01	Integration of End-State and Long-Term Stewardship Options and Decisions with Future Facility- and Land-Use Options	Facility and land-use options may effect, or be effected by, end-state and long-term stewardship options and decisions. Accordingly, as with all other facility and land use proposals, the Land and Facility Operations Department, including the appropriate area planner(s), must be included as an integral part of any end-state and long-term stewardship decision processes. Requirements and/or agreements may be in place to document end-state and long-term stewardship plans and decisions in facility- and land-use plans and reports.	Policy need - relating end-state and LTS options with land-use	NA	NA	NA	NA	NA
ID-6.2.23	Institutional Control	Need to develop institutional control plans from a process control standpoint, fully considering regulatory requirements as does the WIPP closure plan.	Develop institutional plans	NA	NA	NA	NA	NA
NV12	Long-Term Monolayer Arid Site Closure Cover-Enhanced Usability (former NV12-0001-06)	Design, develop, and implementation of long-lived, cost-effective closure covers for disposal units in arid west conditions is needed to enhance the long-term control of disposed waste. The nature and requirements of the final closure cover are dependent on climatic conditions, the waste cell inventory, conceptual models of the vadose zone including subsidence processes, and limitations associated with schedule and budget. The monolayer, or ET cover takes advantage of natural evapotranspiration processes which remove water through evaporation and plant transpiration. The cap serves as a device to store water until evapotranspiration processes have sufficient time to remove the water.	Remediation need - Develop alternative closure covers for arid regions	NA	NA	NA	NA	NA
OH-F040	On-Site Disposal Facility - Bio-Intrusion Layer	A bio-intrusion layer that will prevent intrusion through such avenues as burrowing animals and plant roots is required as part of the vegetative cover system and management regime for the OSDF final cap. The final cover system must be effective for 1000 years, but as a minimum 200 years.	Remediation need: Design disposal cell bio-intrusion layer: implied LTM system	NA	NA	NA	NA	NA
OK01-36	Landtrek Extension of Environmental Information Management System	The goal is to develop tools for the national laboratory staff, DOE staff, regulators, and the public to allow technical and non-technical users to locate, visualize, and interpret DOE's growing wealth of environmental data. Phase I of this project is planned for completion in calendar year 2000, and has been funded by EH-10 and BNL. The proposed Phase II will continue to expand the type and amount of data available, and improve upon tools to access the data.	Data access and storage	NA	NA	NA	NA	NA
ORBW-13 and 13a (same)	Hot Spot Retrieval	Selective excavation of high risk buried materials.	Remediation need -hot spot retrieval	NA	NA	NA	NA	NA

Master List Need Code	Need Title	Narrative	Problem	Contaminant	Media	Stage of Development	Sampling or Detection	Analytical Performance Requirement
ORBW-08	Long-Term Performance Assessments	Predictive capabilities for long-term performance assessment are needed to ensure that performance can be reliably determined and monitored for periods long enough to achieve remedial objectives (ranging from decades to centuries).	No specifics - "predictive capabilities for performance assessments"	Not given	Not given	No info	Not specifics	Not given
ID-6.2.24	Historic Preservation	Cultural preservation must be factored into remedy selection and design of the LTS approach for a given site. Processes, procedures, and techniques are needed to fully incorporate cultural preservation concerns into long-term end state planning so as to maintain these resources for future generations	Cultural preservation policies incorporated in remediation plans	NA	NA	Policy development	NA	NA
ID-6.2.25	Uniform DOE Policy for Stakeholder Issues	There is an overall DOE need to establish a credible national policy and process that addresses stakeholder concerns now and in the future as pertaining to Complex-wide contamination entombment, D&D practices, and end state planning	Develop national DOE Stakeholder policy related to remediation and closure of sites	NA	NA	Policy development	NA	NA
ID-6.2.28	Strong Cost Estimating Tools for LTS	As identified in numerous DOE LTS strategic documents, Agencies, affected stakeholders have identified site remedy life-cycle costs, including stewardship as an important criteria during remedy selection and planning.	Develop cost estimating tools for remedy selection: life-cycle and LTS considerations	NA	NA	Remedy selection cost estimating tools	NA	NA
ID-6.2.27	Reliable Risk Assessment Methodology	As identified in numerous DOE LTS strategic documents, Agencies, affected stakeholders have identified "uncertainty management, cost-benefit analysis and contingency planning" as key criteria to consider during the evaluation of site remedy selection.	Development of risk assessment, cost, and contingency planning as part of remedy selection	NA	NA	Remedy selection process	NA	NA

APPENDIX G: List of Detection Technologies for Organic Compounds in Soils, Vapor, and Ground Water

Volatile Organic and Semi-Volatile Organic Compounds												
Analyte/ Parameter	**Media**	**Range**	**Tech Specs**	**Calibration**	**Deployment**	**Data Collection**	**Manufacturer or Vendor POC**	**Instrument Name & Model**	**Limitations**	**Advantages**	**I.V.**	**Comments**
PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 ug/mL	Electrochemical technique/Ion Specific Electrode; DL = 2 ppm for soils	See ETV report	Tested in ETV Program in humid (ORNL) and controlled conditions		DEXSIL Corp. Hamden, CT 203-288-3509	L2000 PCB/Chloride Analyzer	See ETV report	Field portable (8" x 8" x 4.5"); Throughput= 5-10 samples/hr	ETV	Field Analytical Technique; Weight ~3.5 lbs; minimum training <1 hr
PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 ug/mL	Immunoassay Kit; enzyme conjugate produces a color change that can be detected and measured; DL = 1.5 ppm in soil	See ETV report	Tested in ETV Program in humid (ORNL) and controlled conditions		Strategic Diagnostics, Inc. Newark, DE 302-456-6789	SDI RaPID Assay System for PCB Analysis	See ETV report	Throughput = 10-11 samples/hr	ETV	Field Analytical Technique; light, transportable; 1 hr for initial setup; Minimum training = 2-4 hr; run by single trained operator
PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 ug/mL	Immunoassay Kit; enzyme conjugate produces a color change that can be detected and measured; Interval testing - 1, 5 & 50 ppm intervals in soil	See ETV report	Tested in ETV Program in humid (ORNL) and controlled conditions		Strategic Diagnostics, Inc. Newark, DE 302-456-6789	EnviroGard PCB Test Kit	See ETV report	Throughput = 18 samples/hr	ETV	Field Analytical Technique; 1 hr for initial setup; minimum training = 2-4 hrs
PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 ug/mL	Immunoassay Kit; enzyme conjugate produces a color change that can be detected and measured; interval threshold levels and standards depend on PCB	See ETV report	Tested in ETV Program in humid (ORNL) and controlled conditions		Strategic Diagnostics, Inc. Newark, DE 302-456-6789	D TECH PCB Test Kit	See ETV report	Throughput = 15 samples/hr	ETV	Field Analytical Technique; 1 hr for initial setup; minimum training = 2-4 hrs; semi-quantitative measurements
PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 ug/mL	Immunoassay Kit; PCB in Soil Tube Assay; interval threshold levels 1, 10, 50 ppm in soil; measurements indicate "above or below" threshold levels	See ETV report; kit supplied with calibrators = 1 - 10 ppm	Tested in ETV Program in humid (ORNL) and controlled conditions		EnviroLogix, Inc., Portland, ME 207-797-0300	PCB Soil Tube Assay	See ETV report	Throughput = 8 samples/hr	ETV	Field Analytical Technique; Semi-quantitative results; Minimum training = 4 hrs
PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 ug/mL	Immunoassay Kit; interval threshold levels 1 & 10 ppm	See ETV report	Tested in ETV Program in humid (ORNL) and controlled conditions		HACH Loveland, CO 800-227-4224	PCB Immunoassay Kit	See ETV report	Throughput = 10-13 samples/hr	ETV	Field Analytical Technique; Semi-quantitative results; Minimum training= 2 hrs; Initial setup time = 1 hr

APPENDIX G: List of Detection Technologies for Organic Compounds in Soils, Vapor, and Ground Water

PCB (polychlorinated Biphenyl)	Soils & Solvent extracts	Soil samples = 0.1 - 700 ppm; Extract = 0 -100 u g/mL	Chromatography system equipped with nonspecific SAW detector; MDL = 26 ppm	See ETV report	Tested in ETV Program in humid (ORNL) and controlled conditions		Electronic Sensor Technology Newbury Park, CA 805-480-1994	4100 Vapor Detector	See ETV report	Throughput = 5-6 samples/hr	ETV	Field Analytical Technique; hand-held, portable (35 lb); setup time = 1 hr; training = several hours
PCB or other chlorinated compds	Soils		Colorimetric Indicator Test; 50 ppm level test kit, above/below action level				Dexil Corp. www.dexsil.com	Clor-N-Soil PCB Test Kit		8 min test; $10-15/test		Hand-held, portable; untrained analyst
PCBs, Solvents, BTEX, TPH	Soil & saturated sediments	20-2000 ppm	Colorimetric Indicator Test; hand-held electronic colorimeter digital readout				Dexil Corp. www.dexsil.com	PetroFLAG Hydrocarbon Analyzer		25-30 samples/hr; System cost = $695		Real-time, on-site, weight = 5 lbs, 8"x20"x20"
PCBs, pesticides; halogenated VOC & semi-VOC	water or waste water	100-4000 ppm	Colormetric Indicator Test; disposable test kit; no interference with inorganic chloride					HydroClor Q4000		test<10 min; throughput = 10/hr; $13/test		Portable; hand-held; no training; weight = 1/4 lb; 2"x3"x6"
Organic PCP (pentachlorophenol)	soil	ppm	Colormetric Indicator Test; photochemical reaction; quantitative values; analyte extraction process from soil; sample size 100-250 gms				Envirol, Inc.	Envirol Quick Test		Test = ~30 min; 5 tests/kit		Portable, colorimetric field test; Test Kit contains photometer, volumetric pipetter, and small balance ; 5"x12"x12"; starter kit 8.5 lbs; battery up to 8 hrs
Organic PCP (pentachlorophenol)	water		Colormetric Indicator Test; photochemical reaction							Test = ~30 min; 5 tests/kit		Portable, colorimetric field test;
PAH: Polyaromatic hydrocarbons	soil		Colormetric Indicator Test; photochemical reactions							Test < 20 min;		
PAH: Polyaromatic hydrocarbons	water		Colormetric Indicator Test; hand-held microprocessor & photodiode based single & multi-parameter based colorimeter				HANNA Instruments Inc. Www.hannainst.com	Ion Specific Meters		Throughput < 1 min; no training required		Weight = 10 oz. 1.8"s 3.3"x7.1" Battery up to 40 hrs

Total petroleum hydrocarbon (TPH)	soil	MDL: for sample extract 2.0 mg/L for weathered gas, 10 mg/L for heavy oils; assuming 5 gms of soil is extracted with 20 ml of solvent - then MDL = 8 and 40 mg/Kg	Colormetric indicator test based on Friedel-Crafts alkylation reaction. Kit contains hand-held absorbance photometer, a balance, and enough supplies to complete 8 soil analyses				CHEMetrics, Inc. Calverton, VA POC: Henry Castaneda 800-356-3072	RemediAid™ Total Petroleum Hydrocarbon Starter Kit	This technique responds to all hydrocarbons as long as they contain aromatics including gas, diesel, and heavier than diesel such as lubricating oil.	All chemicals supplied are vacuum-sealed, minimizing user error.	Scheduled for SITE Pgm	Test to be carried out by individuals with basic wet chemistry skills.
Total petroleum hydrocarbon (TPH)	soil	MDL for Model CVH = 3 mg/kg and for HATR-T = 20 mg/Kg	Based on infrared analysis which includes a single-beam fixed-wavelength, NDIR filter-based spectrophotometer with dual detector system. The reference wavelength automatically corrects spectrophotometer readings for fluctuations. Uses pulsed infrared light source instead of a "chopper".				Wilks Enterprise, Inc. Boulder Creek, CA POC: Sandy Rintoul 831-338-7459	Infracal TOG/TPH Analyzer, Models CVH and HATR-T		Measures aromatic and aliphatic hydrocarbons in gas, diesel, and other petroleum products that a are heavier than diesel. Designed for individuals with basic wet chemistry skills	Scheduled for SITE Pgm	User can purchase a field sampling kit that contains a balance and enough supplies to complete 75 soil sample analyses. Can also purchase optional software package, InfraWin that manages and present data.

Total petroleum hydrocarbon (TPH)	soil	MDL = 1 mg/Kg for soil	Based on infrared analysis which includes a single-beam, fixed wavelength, NDIR filter-based spectrophotometer. Sample extracted with proprietary S-316 extraction solvent, which is nonflammable, nontoxic, and relatively nonvolatile because of its low vapor pressure.				Horiba Instruments, Inc. Irvine, CA 800-4HORIBA POC: Jim Vance	OCMA-350	Kit requires infrared spectrophotometer, a proprietary quartz cuvette, syringes (supplied by developer) and balance and glassware. Can also get solvent reclaimer and ultrasonic mexier used to disperse soil sample in solvent.	Measures aromatic and aliphatic hydrocarbons in gas, diesel, and other petroleum products that a are heavier than diesel. Solvent reclaimer recycles the extraction solvent which is difficult to dispose of and can reduce costs by up to 90%.	Scheduled for SITE Pgm	Infrared spectrophotometer uses a grounded AC power source or a DC voltage converter that plugs into an automatic cigarette lighter. Users expected to have basic wet chemistry skills.
Total petroleum hydrocarbon (TPH)	soil	MDL = 10 mg/Kg for hydraulic fluid to 1,000 mg/Kg for weathered gas.	Based on emulsion turbidimetry which uses a proprietary organic solvent mixture and proprietary developer solution that stabilizes the emulsion. Uses 10 gm samples.				DEXSIL Corp. Hamden, CT 203-288-3509 POC: Dr. Ted Lynn	PetroFLAG Hydrocarbon Test Kit for Soil		Measures aromatic and aliphatic hydrocarbons in gas, diesel, and other petroleum products that are heavier than diesel. Designed for individuals with basic wet chemistry skills	Scheduled for SITE Pgm	Test kit includes: hand-held, battery-powered turbidimeter; a balance, and enough supplies to analyze 10 soil samples - all packaged in carrying case

Total petroleum hydrocarbon (TPH)	soil	MDL = 50 ug/KG for various petroleum contaminated soil samples	Based on ultraviolet fluorescence spectroscopy. Grams/32 software developed by Galactic Industries is used to control the Luminoscope and to manage data collected by the device.				Environmental Systems Corp. Knoxville, TN 423-688-7900 POC: Dr. George Hyfantis	Synchronous Scanning Luminoscope	Measures aromatic hydrocarbon conc. in soil. Aliphatic concentrations can be estimated from aromatic/aliphatics hydrocarbon ratios.	Designed for individuals with basic analytical chemistry skills.	Scheduled for SITE Pgm	Operated with a grounded AC power source or a DC voltage converter that plugs into an auto cigarette lighter. The sampling kit contains enough supplies to analyze 25 soil samples + 1 L of extraction solvent. Other equipment required: balance, centrifuge, test tube shaker, and laptop computer.
Total petroleum hydrocarbon (TPH)	soil	MDL = 0.08 mg/Kg for No. 6 fuel oil to 3.9 mg/Kg for weathered gas in soil samples.	Based on ultraviolet fluorescence spectroscopy. Test kit includes a portable fluorometer fitted with excitation and emission filters. Light source is a mercury vapor lamp. Software has been developed to manage and report data generated by the device.				siteLAB Corp. Hanover, NH 877-SITELAB POC: Stephen Greason	UVF-3100A	Measures aromatic hydrocarbon conc. in soil. However, aromatic and aliphatic hydrocarbon ratios can be established for the site, then the software can estimate aliphatic hydrocarbon conc.	Designed for individuals with basic analytical chemistry skills. Operated using grounded AC power source or a DC voltage converter that plugs into auto cigarette lighter.	Scheduled for SITE Pgm	Test kit includes: fluorometer, quartz cuvettes, and siteLAB software, cables to operate using a car cigarette lighter and to connect the fluorometer to a computer and battery-powered balance. Calibration kits for a variety of TPH stds are also available.
Total petroleum hydrocarbon (TPH)	soil	MDL = 10 mg/Kg for gas to 40 mg/Kg for mineral spirits extracted from soil samples	Based on a combination of immunoassay (specifically enzyme-linked immunosorbent assay) and colorimetry. The System uses differential photometer that compares absorbance of colored solution to reference standard.				Strategic Diagnostics, Inc. Newark, DE 800-544-8881 POC: Joseph Daulick	EnSys Petro Test System	Measures most aromatic and some aliphatic hydrocarbons.	Designed for individuals with basic wet chemistry skills.	Scheduled for SITE Pgm	Test System includes:SDI Sample Extraction Kit (12 soil extractions). EnSys/EnviroGard Common Accessory kit contains photometer and balance. Photometer is compact and battery powered.

APPENDIX G: List of Detection Technologies for Organic Compounds in Soils, Vapor, and Ground Water

Petroleum derived substances	soil/water	1 - 1000 mg/kg soil; 0.1 - 20 mg/L water	Colorimetric Indicator Test; MDL < 1 ppm; 5 gm soil samples; 500 ml water samples				H.E.L.P. Inc www.hanbytest.com	Hanby Test Kit		6 min/test for soils; 8 min/test for water	RCI & SITE Prg	8"x14"x18"; weight = 8 lbs
TPH or VOCs	gas/water	MDL for TPH in water = 1-700 ppm ; 10-20,000 ppm in soil gas	Fiber Optic Chemical Sensor from FCI			Data retrieved every 10 secs	Geotech Environmental Equipment, Inc. Www.geotechenv.com	In-Situ Sense Soil Gas Sampling System	Interference with free product; training required	Throughput 360/hr; battery up to 8 hrs		Downhole measurements deployed by dual wireline system in 2" cased holes or dual tube direct push continuous vertical "profiling"; 3 part system: direct push deployment, fiber optic sensor, sampling system
TNT	soil		Colorimetric Indicator Test; photochemical reaction							Test < 20 min; 10 tests/kit		
VOCs	soil/water	working range - 1-50 ppb; DL = 0.1 to 50 ug/L in water	Field Portable Gas Chromatograph	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and McClellan AFB in Sacramento, CA		Sentex Systems, Inc. Ridgefield, NJ 201-945-3694	Scentograph Plus II	See ETV report	Throughput = 2 samples/hr Cost $35,000 Operational cost $25/8 hr day Weight=80 lbs, size of suitcase	ETV	Includes 3 modules: purge & trap unit, GC, notebook computer; sample processing by technician but calibration data processing requires higher level
VOCs	soil gas, water, soil	MDL: 5 ppb for soil gas; 5 ppb ug/kg soil; 5 ug/L for water	Field Portable Gas Chromatograph - Mass Spectrometer	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and Wurtsmith AFB in Oscoda, MI		Viking Instruments Corp. Chantilly, VA 703-968-0101	SpectraTrack™ 672	Requires skilled operator - 1 week training for chemist; See ETV report	Throughput = 2 samples/hr for soil extracts & water; 4 samples/hr for soil gas Cost=$145 K	ETV	Setup time = 30 mins; weight = 145 lbs
VOCs	soil gas, water, air	5-10 ug/L	Field Portable Gas Chromatograph	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and Wurtsmith AFB in Oscoda, MI		Perkin-Elmer, Photovac Monitoring Instruments, Wilton, CT 203-761-2557	Photovac Voyager	See ETV report	Throughput = 1-3 samples/hr Cost = $24 K Operational cost = $25/8 hr day	ETV	~15 lbs; accessories for water analysis 33 lbs; training = 1 day

APPENDIX G: List of Detection Technologies for Organic Compounds in Soils, Vapor, and Ground Water

VOCs	soil gas, water, soil	MLD: 1 ppb soil gas, 1 ug/L water, 50 ug/Kg soil	Field Portable Gas Chromatograph - Mass Spectrometer	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and Wurtsmith AFB in Oscoda, MI		Bruker-Franzen Analytical Systems, Inc. Billerica, MA 508-667-9580	EM 640™	Requires 1 week training, skilled operator; See ETV report	Throughput = 5 samples/hr Cost: $170 K	ETV	Field transportable package
VOCs	water	DL = 5-10 ug/L for chlorinated VOCs in water	Field Portable Gas Chromatograph - Mass Spectrometer	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and McClellan AFB in Sacramento, CA		Inficon, Inc. East Syracuse, NY 315-434-1100	HAPSITE	See ETV report	Throughput = 2-3 samples/hr; Cost: $75-95 K; operational cost: $150/8 hr day	ETV	Field Portable GC/MS Weight: 35 lbs; head space sampling accessory = 15 lbs
VOCs	water	DL = 5 ug/L	Photoacoustic Infrared Monitor	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and McClellan AFB in Sacramento, CA		Innova AirTech Instruments Denmark 714-974-5560	Type 1312 Multi-gas Monitor	See ETV report	Throughput = 1-2 samples/hr Cost: $28 K Maintenance cost: $100/yr	ETV	Field Portable Weight: 30 lbs; training = 1 day
VOCs	water	DL = 10-100 ug/L	Field Portable Gas Chromatograph	See ETV report	Tested in ETV Program under 2 environmental conditions: SRS in SC and McClellan AFB in Sacramento, CA		Electronic Sensor Technology Newbury Park, CA 805-480-1994	Model 4100	See ETV report	Throughput = 2-3 water samples/hr Cost: $25 K	ETV	Field Portable GC Weight: 35 lbs; large brief case size
VOCs	water, soil	ppb	TCE Optrode Detection System for groundwater wells		Tested at Homestead AFB under EPA Technology Innovation Office: 100 ppb measurements		Burge Environmental Tempe, AZ 480-968-5141 www.burgenv.com	TCE Sensor		Throughput = 3-6 analysis time	TIO/ AFC EE	Real-time TCE Sensor & automated monitoring system in gw well for 6 mos; multi-level sampler
Carbon tetrachloride	vapors of chlorinated solvents	MDL = 0.5 ppb in air; Max DL = 10,000 ppb	Sensor consists of 2 platinum electrodes encapsulated in rare earth salts; conductivity of salts depended on chlorinated solvent concentration,		Tested at INEEL and 3 applications at Hanford	Remote data acquisition.	Transducer Research Inc. POC Roger Williams 651-490-2863	RCL Sensor (sold as InspectAir-MC under TSI Inc.- purchaser of TRI)	Commerciall y available but discontinued production due to lack of sales.	Selectivity to chlorinated compounds only		300 ml sample required. Cost estimated at $17,400 in 1996. Additional $1,000 for necessary samplers. ***Taken from MSE report*

Carbon tetrachloride and many other VOCs	vapor or head space of water sample	MDL = 2 ppb for CCl4 with additional absorbing tube; see MSE Report for MDLs of other compounds	Based on GC/SAW technology. See above under PCB compounds. See ETV report.			Remote data acquisition.	Electronic Sensor Technology Newbury Park, CA 805-480-1994 POC: Ken Zeiger	Model 4100		EST has a GSA contract with negotiated gov rates. Cost about $15,000. 90 sec analysis/sample.	ETV	Tested under EPA ETV program for well head testing. ***See MSE report*.
Carbon tetrachloride and many other VOCs	water	MDL = 1-5 ppb	DSITMS is based on using an ion trap mass spectrometer as a continuous real-time monitor of multiple chemicals simultaneously as they are being introduced into the ion trap cell. Minimal or no sample preparation or chromatographic separation required.		Field demonstrated for many applications at multiple sites.	Remote data acquisition.	Teledyne Electronic Technologies and Finnegan MAT, Inc.	Direct Sampling Ion Trap Mass Spectrometry (DSITMS)	Requires trained chemist as operator.	Generates approximately 10 mass spectra/sec and records the spectra. Costs ~ $70-100K depending on features.		*Costs**See MSE report*
Molecular Species; e.g. VOCs, inorganic ions, chlorinated hydrocarbons	Liquids, solid surfaces	Detection limits typ. 1 to 10 millimolar	Based on vibrational spectroscopy; optical probe coupled to spectrometer via fiber optic cable	Site specific	Deploy in ground by cone penetrometer, in tanks by cable/reel mechanism	At-site PC data collection	EIC Laboratories Inc., Norwood, MA	Raman probe	Detects molecular species only, may not be suitable for trace analysis	commercial product, tank probe version designed for >2 yr service life		Demonstrated at SRS with cone penetrometer, being prepared for deployment in SRS HLW tank for corrosion monitoring

APPENDIX H: List of Detection Technologies for Metals in Soils and Ground Water

Drinking Water Standards			Soil Screening Levels*			
Metal	MCLs (ppb)		Metal	Ingestion (mg/L)*	Inhalation (mg/L)*	Clean Up Levels (mg/kg)
As	50		As	0.4	380	7.5 or SB
Ba	2 mg/L		Ba	-	-	300 or SB
Cd	5		Cd	39	920	1.0 or SB
Cr	100		Cr	390	140	10 or SB
Pb	15		Pb	400	-	SB**
Hg	2		Hg	23	7	0.1
Se	50		Se	390	-	2.0 or SB
Ag	390 mg/L		Ag	390	-	SB

SB - Soil Background
* Taken from Soil Screening Levels from EPA Soil Screening Guidance
** Background levels for PB vary. Undeveloped, rural areas 4 to 41 ppm.
Metropolitan or suburban areas or near highways 200 to 500 ppm.

Analyte/Parameter	Media		Range	Tech Specs	Calibration	Deployment	Data Collection	Manufacturer or Vendor POC	Instrument Name & Model	Limitations	Advantages	I.V.	Comments
As	Water		ppb	Microsample XRF: Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - Kevex Spectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
As	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 20 & 10??				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				DL for As is representative of low levels of Pb. High Pb levels tend to increase As DL. ***Data taken from FIU*
As	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, *in situ* analysis streamline remediation process & reduce costs.		***Data taken from FIU document*
As	Soil, Wastewater, Water		ppm-ppt	Electrochemical: Anodic Stripping Voltammetry (ASV) used with Nano-Band Electrode. With ASV-plating proportionate to detection limit. ppm-instantaneous, ppb-20 sec or less, & ppt-1-3 min. Iridium & gold electrode.	5% accuracy when calibrated directly via method of standard additions. 10% when calibration curve is built before measuring unknowns. 20%-40% when operating uncalibrated.	Laptop computer with Windows-based software package combined with electrode	Real-time, ppm detection limits for all metals with redox potentials between -1.3V & +1.0V. Detection limits of 0.1 ppb for directly platable metals via Anodic Stripping Voltammetry (ASV)	Trace Detect, Ph. 206-523-2009, www.tracedetect.com	Nano-Band Explorer	Manually operated in field. Most likely interfering species Cu, Hg, Zn, & Bi, because stripping peaks of Hg & Bi are close to As stripping peak & Cu-Zn & Cu-As complexes can form at electrode.	1 electrode for 5?? elements simultaneously		Electrochemical techniques not only measure total As(III) &As(V) but also differential measurement since As(III) & As(V) exhibit different electrochemical behavior. ***Data taken from FIU document*
As	soil		DL = 100 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA		TN Spectrace, Round Rock, TX 512-388-9100	Spectrace TN 9000 Field Portable X-ray Fluorescence Analyzer		Throughput = 8.5-10.5 analyses/hr; in situ measurements	ETV	Cost = $56,000 or $6k/month to lease; less than 20 lbs; battery operated up to 8 hrs. ***Data taken from FIU document*
As	soil		DL = 360 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		HNU Systems, Inc. Newton Highlands, MA 617-964-6690	HNU SEFA-P Analyzer		Throughput = 7-8 analyses/hr, in situ definitive measurements	ETV	Cost = $49,000; ~50 lbs
As	soil		DL = 225 mg/kg	Field Portable x-ray Fluorescence Analyzer; 3.5 lb scanner + 11 lb control console		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Scitec Corp. Kennewick, WA 800-466-5323	MAP Spectrum Analyzer		Throughput = 9-12 samples/hr, in situ definitive measurements	ETV	Cost = $32,000, or lease for $4,675/month
Ba	Water		ppb	Microsample XRF:Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
Ba	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 35 & 25				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				***Data taken from FIU document*

Ba	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, *in situ* analysis streamline remediation process & reduce costs.		***Data taken from FIU document*
Ba	soil		DL = 100 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA		TN Spectrace, Round Rock, TX 512-388-9100	Spectrace TN 9000 Field Portable X-ray Fluorescence Analyzer		Throughput = 8.5-10.5 analyses/hr; in situ measurements	ETV	Cost = $56,000 or $6k/month to lease; less than 20 lbs; battery operated up to 8 hrs.
Ba	soil		DL = 330 mg/kg`	Field Portable x-ray Fluorescence Analyzer; Electronics self contained case= 5 lbs.; surface analyses probe system = 3 lbs		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Metorex, Inc. Princeton, NJ 609-406-9000	X-MET 920-MP	Requires training & field experience	Throughput = 8-14 analyses/hr, in situ measurements	ETV	Cost = $36,000, or lease for $3,633/month; battery operated up to 8 hrs
Ba	soil		DL = 1150	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		HNU Systems, Inc. Newton Highlands, MA 617-964-6690	HNU SEFA-P Analyzer		Throughput = 7-8 analyses/hr, in situ definitive measurements	ETV	Cost = $49,000; ~50 lbs
Cd	Water		ppb	Microsample XRF:Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		
Cd	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 35 & 25				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				
Cd	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, *in situ* analysis streamline remediation process & reduce costs.		
Cd	Soil, Wastewater		ppm-ppt	Electrochemical: Anodic Stripping Voltammetry (ASV) used with Nano-Band Electrode. With ASV-plating proportionate to detection limit. ppm-instantaneous, ppb-20 sec or less, & ppt-1-3 min. Iridium electrode.	5% accuracy when calibrated directly via method of standard additions. 10% when calibration curve is built before measuring unknowns. 20%-40% when operating uncalibrated.	Laptop computer with Windows-based software package combined with electrode	Real-time, ppm detection limits for all metals with redox potentials between -1.3V & +1.0V. Detection limits of 0.1 ppb for directly platable metals via Anodic Stripping Voltammetry (ASV)	Trace Detect, Ph. 206-523-2009, www.tracedetect.com	Nano-Band Explorer	Manually operated in field	1 electrode for 5 elements simultaneously		***Data taken from FIU document*
Cd	soil		DL = 100 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA		TN Spectrace, Round Rock, TX 512-388-9100	Spectrace TN 9000 Field Portable X-ray Fluorescence Analyzer		Throughput = 8.5-10.5 analyses/hr; in situ measurements	ETV	Cost = $56,000 or $6k/month to lease; less than 20 lbs; battery operated up to 8 hrs. ***Data taken from FIU document*
Cr	Water		ppb	Microsample XRF: Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
Cr	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 220 & 150				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				***Data taken from FIU document*
Cr	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, in-situ analysis streamline remediation process & reduce costs.		***Data taken from FIU document*

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Cr	water			Electrochemical quartz crystal microbalance (EQCM) which combines piezoelectric nanobalance technology with stripping potentiometric analysis. DL for chromate 111 ppb.				BIODE, Inc; www.biode.com 207-856-6977			Can distinguish Cr(VI) from Cr(III), Hg(II) & Cu(II).		***Data taken from FIU document*
Cr	soil		DL = 200 - 500 mg/kg depending on source	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA		TN Spectrace, Round Rock, TX 512-388-9100	Spectrace TN 9000 Field Portable X-ray Fluorescence Analyzer	XRF does not respond well to Cr; DL = 5-10 times higher than lab method	Throughput = 8.5-10.5 analyses/hr; in situ measurements	ETV	Cost = $56,000 or $6k/month to lease; less than 20 lbs; battery operated up to 8 hrs. ***Data taken from FIU document*
Cr	soil, water		ppm	SIBS (Spark Induced Breakdown Spectroscopy); MDL = 10 ppmw soils; 5 ppms water; Interference - none to date				Physical Sciences, Inc. 978-689-0003			Portable, real-time measurements; sample size 0.5 gms		
Cr	soil		DL = 900 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Niton Corporation. 617-275-9275, www.niton.com	Niton XL Spectrum Analyzer		Throughput = 20-25 analyses/hr; in situ definitive measurements	ETV	Cost = $11,990, less than 3 lbs, battery operated up to 8 hrs.
Cr	soil, sludges, and other solids		DL = 210 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Metorex, Inc. Princeton, NJ 609-406-9000	X-MET 920-P; X-MET 940; both models have equivalent performance characteristics but redesign of the 920-P led to smaller and lighter version X-MET 940		Throughput = 10-12 analyses/hr, in situ definitive measurements	ETV	Cost = $55,000, or lease for $6,000/month
Cr	soil		DL = 115 mg/kg	Field Portable x-ray Fluorescence Analyzer; Electronics self contained case= 5 lbs.; surface analyses probe system = 3 lbs		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Metorex, Inc. Princeton, NJ 609-406-9000	X-MET 920-MP	Requires training & field experience	Throughput = 8-14 analyses/hr, in situ definitive measurements	ETV	Cost = $36,000, or lease for $3,633/month; battery operated up to 8 hrs
Pb	Soil, Water		ppm	SIBS: AFS of metal sample excited with electric spark. Detection limit for lead in soil-10 & 25 µg/g & water-3-4 mg/L. Less than 15 min per sample. Signal intensity vary with matrix				Physical Sciences, Inc.					***Data taken from FIU document*
Pb	Water		ppb	Microsample XRF:Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
Pb	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 20 & 10				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				***Data taken from FIU document*
Pb	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, in-situ analysis streamline remediation process & reduce costs.		***Data taken from FIU document*
Pb	Soil, Wastewater		ppm-ppt	Electrochemical: Anodic Stripping Voltammetry (ASV) used with Nano-Band Electrode. With ASV-plating proportionate to detection limit. ppm-instantaneous, ppb-20 sec or less, & ppt-1-3 min. Iridium electrode.	5% accuracy when calibrated directly via method of standard additions. 10% when calibration curve is built before measuring unknowns. 20%-40% when operating uncalibrated.	Laptop computer with Windows-based software package combined with electrode	Real-time, ppm detection limits for all metals with redox potentials between -1.3V & +1.0V. Detection limits of 0.1 ppb for directly platable metals via Anodic Stripping Voltammetry (ASV)	Trace Detect, Ph. 206-523-2009, www.tracedetect.com	Nano-Band Explorer	Manually operated in field	1 electrode for 5 elements simultaneously		***Data taken from FIU document*
Pb	soil		DL = 115 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA		TN Spectrace, Round Rock, TX 512-388-9100	Spectrace TN Pb Field Portable X-ray Fluorescence Analyzer		Throughput = 20-25 analyses/hr; in situ measurements	ETV	Cost = $39,500 or $5,500/month to lease; less than 20 lbs; battery operated up to 8 hrs. ***Data taken from FIU document*
Pb	soil		DL = 165 mg/kg	Field Portable x-ray Fluorescence Analyzer; 3.5 lb scanner + 11 lb control console		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Scitec Corp. Kennewick, WA 800-466-5323	MAP Spectrum Analyzer		Throughput = 9-12 samples/hr, in situ definitive measurements	ETV	Cost = $32,000, or lease for $4,675/month

Hg	Water		ppb	Microsample XRF:Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
Hg	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 25 & 15				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				***Data taken from FIU document*
Hg	Soil, Wastewater		ppm-ppt	Electrochemical: Anodic Stripping Voltammetry (ASV) used with Nano-Band Electrode. With ASV-plating proportionate to detection limit. ppm-instantaneous, ppb-20 sec or less, & ppt-1-3 min. Iridium electrode.	5% accuracy when calibrated directly via method of standard additions. 10% when calibration curve is built before measuring unknowns. 20%-40% when operating uncalibrated.	Laptop computer with Windows-based software package combined with electrode	Real-time, ppm detection limits for all metals with redox potentials between -1.3V & +1.0V. Detection limits of 0.1 ppb for directly platable metals via Anodic Stripping Voltammetry (ASV)	Trace Detect, Ph. 206-523-2009, www.tracedetect.com	Nano-Band Explorer	Manually operated in field	1 electrode for 5 elements simultaneously		***Data taken from FIU document*
Hg	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, in-situ analysis streamline remediation process & reduce costs.		***Data taken from FIU document*
Hg	soil			Colorimetric Test Kit; test based on Hg selective enzyme: MDL = 1 mg/kg				Mercury Science Inc.	Mercury SPOT Kit	Possible interference with high conc. Of Cu, Ag, Au	Throughput = 20 samples/hr; sample size 2-10 gm		Field test kits 3"x11"x9"; 3 lbs, power supply not required. ***Data taken from FIU document*
Hg	vapor		0 - 0.999 mg/m^3	Automatically regenerates between samples.				Arizona Instrument: 800-528-7411 www.azic.com	Jerome® 431-X Mercury Vapor Analyzer	Eliminates interference common to ultraviolet analyzers, i.e. water, HCs	Portable, handheld, 13 sec response, battery operated up to 6 hrs, weight 7 lbs, Dimensions: 6"x13"x4"		***Data taken from FIU document*
Se	Water		ppb	Microsample XRF:Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
Se	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 20 & 10				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				***Data taken from FIU document*
Se	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, in-situ analysis streamline remediation process & reduce costs.		***Data taken from FIU document*
Ag	Water		ppb	Microsample XRF: Sample dried on Prolane sample support films & residue analyzed. Detection limit dependent on matrix.			X-ray intensities vs conc. plotted.	XRF - KevexSpectrace Instruments, Sunnyvale, CA		High TDS results in higher background & higher detection limits than with low TDS. Best for surface water with low TDS.	1. Screen sample on site before certified measurements. 2. Less preparing time. 3. Stirring optional 4. No oxygen removal. 5. Little to no interference.		***Data taken from FIU document*
Ag	Sand		mg/kg (ppm)	Multi-element XRF analyzer. 99.7% confidence level. For 60s & 120s testing time, DL = 190 & 130				Niton Corporation. Ph. 978-670-7460, www.niton.com	Niton XL-700S Series				DL for Ag are artificially high due to Sn & Ag detector collimator used in the instrument. Future hardware modifications will improve DL. ***Data taken from FIU document*

Ag	Soil (Subsurface)			LIBS: High energy laser pulse delivered to subsurface via cone penetrometer. For this LIBS system, DL for Pb in soils 10-40 ppm.			Observation of the wavelength and intensities of the emission lines, which depends on type & amount of material present within plasma.	Science & Engineering Associates, Inc. Ph. 505-884-2300, www.seabase.com			Field deployable. Penetrometer deployment enable high resolution mapping. Real-time, in-situ analysis streamline remediation process & reduce costs.		***Data taken from FIU document*
Ag	Soil, Wastewater		ppm-ppt	Electrochemical: Anodic Stripping Voltammetry (ASV) used with Nano-Band Electrode. With ASV-plating proportionate to detection limit. ppm-instantaneous, ppb-20 sec or less, & ppt-1-3 min. Iridium & gold electrode.	5% accuracy when calibrated directly via method of standard additions. 10% when calibration curve is built before measuring unknowns. 20%-40% when operating uncalibrated.	Laptop computer with Windows-based software package combined with electrode	Real-time, ppm detection limits for all metals with redox potentials between -1.3V & +1.0V. Detection limits of 0.1 ppb for directly platable metals via Anodic Stripping Voltammetry (ASV)	Trace Detect, Ph. 206-523-2009, www.tracedetect.com	Nano-Band Explorer	Manually operated in field	1 electrode for 5 elements simultaneously		***Data taken from FIU document*
Cu, Zn, Ni, Fe, Sb	soil		DL = 100 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		TN Spectrace, Round Rock, TX 512-388-9100	Spectrace TN 9000 Field Portable X-ray Fluorescence Analyzer		Throughput = 8.5-10.5 analyses/hr; in situ definitive measurements	ETV	Cost = $56,000 or $6k/month to lease; less than 20 lbs; battery operated up to 8 hrs.
As, Ba, Cu, Pb, Zn, Ni, Fe, Cd, Sb	soil		DL = 130 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Niton Corporation. 617-275-9275, www.niton.com	Niton XL Spectrum Analyzer		Throughput = 20-25 analyses/hr; in situ definitive measurements	ETV	Cost = $11,990, less than 3 lbs, battery operated up to 8 hrs.
Sb, Pb	soil		DL = 120 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		HNU Systems, Inc. Newton Highlands, MA 617-964-6690	HNU SEFA-P Analyzer		Throughput = 7-8 analyses/hr, in situ definitive measurements	ETV	Cost = $49,000; ~50 lbs
Cu	soil		DL = 225 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		HNU Systems, Inc. Newton Highlands, MA 617-964-6690	HNU SEFA-P Analyzer		Throughput = 7-8 analyses/hr, in situ definitive measurements	ETV	Cost = $49,000; ~50 lbs
Cu	soil		DL - 525 mg/kg	Field Portable x-ray Fluorescence Analyzer; 3.5 lb scanner + 11 lb control console		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Scitec Corp. Kennewick, WA 800-466-5323	MAP Spectrum Analyzer		Throughput = 9-12 samples/hr, in situ definitive measurements	ETV	Cost = $32,000, or lease for $4,675/month
Fe	soil		DL = 900 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		HNU Systems, Inc. Newton Highlands, MA 617-964-6690	HNU SEFA-P Analyzer		Throughput = 7-8 analyses/hr, in situ definitive measurements	ETV	Cost = $49,000; ~50 lbs
Zn	soil		DL = 25 mg/kg	Field Portable x-ray Fluorescence Analyzer; 3.5 lb scanner + 11 lb control console		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Scitec Corp. Kennewick, WA 800-466-5323	MAP Spectrum Analyzer		Throughput = 9-12 samples/hr, in situ definitive measurements	ETV	Cost = $32,000, or lease for $4,675/month
Zn	soil		DL = 990 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		HNU Systems, Inc. Newton Highlands, MA 617-964-6690	HNU SEFA-P Analyzer		Throughput = 7-8 analyses/hr, in situ definitive measurements	ETV	Cost = $49,000; ~50 lbs
As, Ba, Cu, Pb, Zn, Ni, Cd	soil, sludges, and other solids		DL = 100 mg/kg	Field Portable x-ray Fluorescence Analyzer		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Metorex, Inc. Princeton, NJ 609-406-9000	X-MET 920-P; X-MET 940; both models have equivalent performance characteristics but redesign of the 920-P led to smaller and lighter version X-MET 940		Throughput = 10-12 analyses/hr, in situ definitive measurements	ETV	Cost = $55,000, or lease for $6,000/month
As, Cu, Pb, Zn	soil		DL was < or = 50 mg/kg	Field Portable x-ray Fluorescence Analyzer; Electronics self contained case= 5 lbs.; surface analyses probe system = 3 lbs		Demonstrated in ETV program at RV Hopkins Site, Iowa and ASARCO site, WA. Results reported in ETV report.		Metorex, Inc. Princeton, NJ 609-406-9000	X-MET 920-MP	Requires training & field experience	Throughput = 8-14 analyses/hr, in situ definitive measurements	ETV	Cost = $36,000, or lease for $3,633/month; battery operated up to 8 hrs
Hexavalent Chromium Sensors and Technologies under Development													
Cr	water		Max DL = 1,000 - 5,000 ppb; Min DL = 1-10 ppb	Stripping Based Metal Sensor: expected availability 15 months (Mid 2002); no waste issues expected; quantitative data expected			Remote data acquisition should be possible	Instrumentation Northwest, Inc. Sephen Hall - info@inwusa.com					Cost estimated range: $1,000 to $3,000 ***Taken from MSE report*
Cr	water		Max DL = high ppm; Min DL = 100 ppt	Nano-Band Electrodes; 8 months from testing and 1 yr (mid-2002) from commercial; no waste issues expected; quantitative data expected			Remote data acquisition should be possible	TraceDetect Wendy Wahl - wendyw@tracedetect.com					Cost estimate: $500 per Nano-Band Electrode and $7,000 for complete system ***Taken from MSE report*

Cr	water		Max DL: no limit; Min DL = ppb levels	Ultramicroelectrode Array Sensor; availability 2003 to 2004; no waste issues expected			Remote data acquisition should be possible	Lynntech, Inc. Dr. Adrian Denvir - info@lynntech.com					Cost estimate: $5000 per unit ***Taken from MSE report*
Cr	water		Min DL = ppb levels	UMEA Sensor; quantitative data expected; no waste issues expected; availability expected in 2004			Remote data acquisition should be possible	Tufts University Samuel Kounaves - 617-627-3124 samuel.kounaves@tufts.edu					***Taken from MSE report*
Cr	water		Max DL = 1 x l0-2 M; Min DL = 1 x l0-9 M	Microcantilever Sensor: sample size = micro liters; availability unknown			Remote data acquisition should be possible	Oak Ridge National Lab Thomas Thundat - ugt@ornl.gov					***Taken from MSE report*

APPENDIX I: List of Detection Technologies for Radionuclides in Soils and Ground Water

Raman Probe Technology												
Analyte/ Parameter	**Media**	**Range**	**Tech Specs**	**Calibration**	**Deployment**	**Data Collection**	**Manufacturer or Vendor POC**	**Instrument Name & Model**	**Limitations**	**Advantages**	**I.V.**	**Comments**
Molecular Species; e.g. VOCs, inorganic ions, chlorinated hydrocarbon s	Liquids, solid surfaces	Detection limits typ. 1 to 10 millimolar	Based on vibrational spectroscopy; optical probe coupled to spectrometer via fiber optic cable	Site specific	Deploy in ground by cone penetrometer, in tanks by cable/reel mechanism	At-site PC data collection	EIC Laboratories Inc., Norwood, MA	Raman probe	Detects molecular species only, may not be suitable for trace analysis	commercial product, tank probe version designed for >2 yr service life		Demonstrated at SRS with cone penetrometer, being prepared for deployment in SRS HLW tank for corrosion monitoring

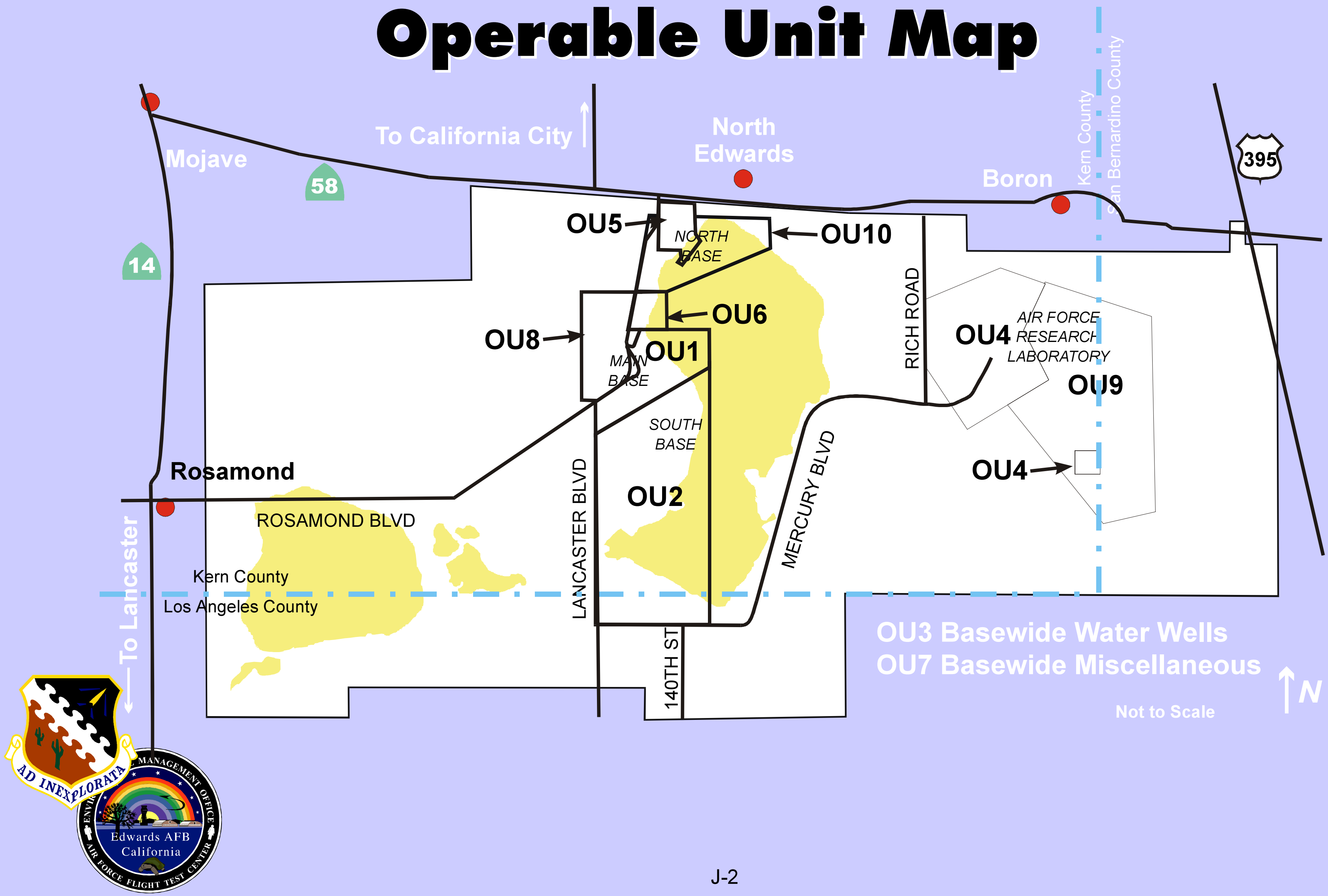
Use of Sensors to Support Long-Term Monitoring and Long-Term Operations at Edwards AFB, Ca

Robert W. Wood

Environmental Restoration Division

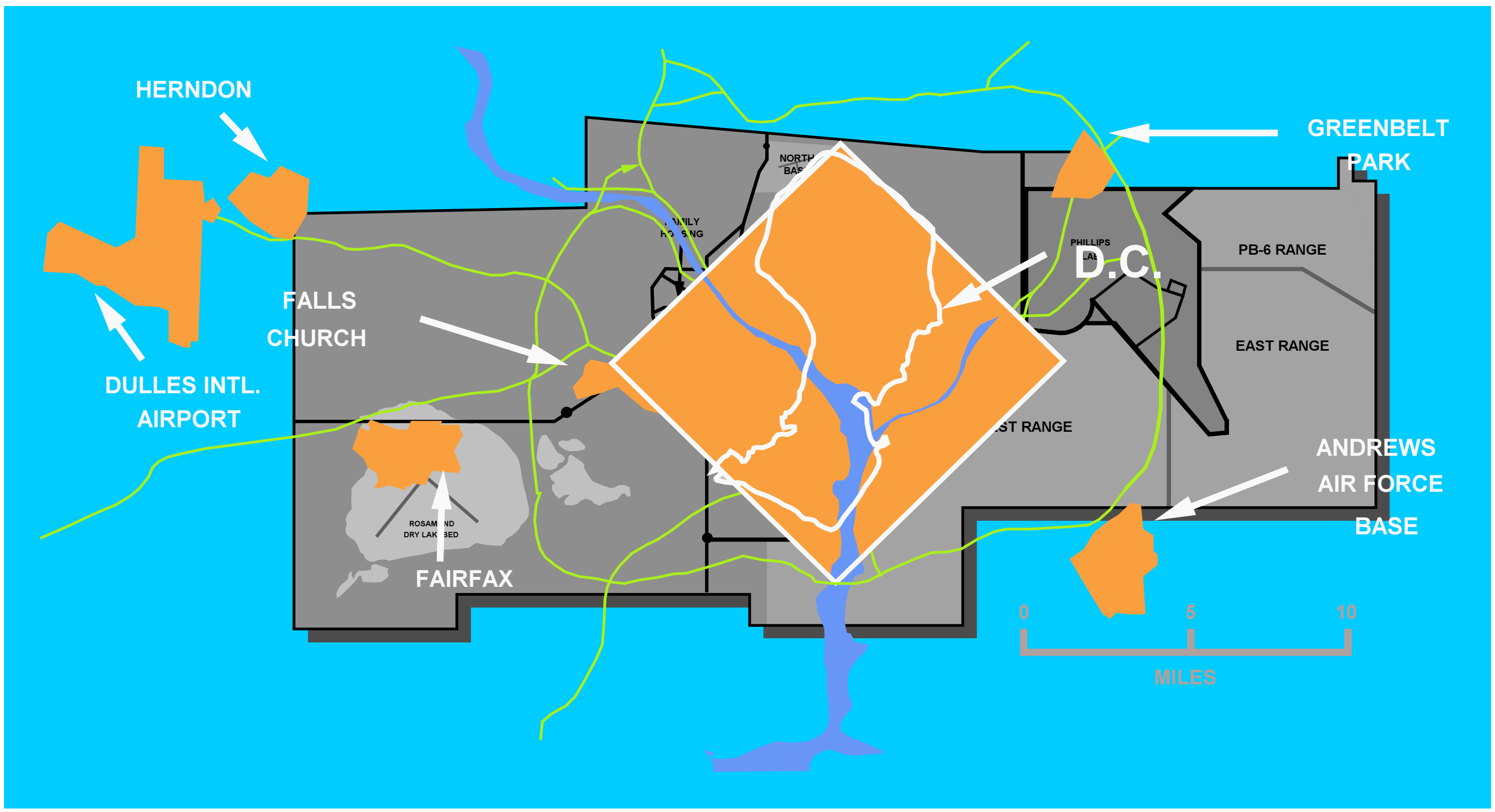
Edwards Air Force Base, Ca

Operable Unit Map

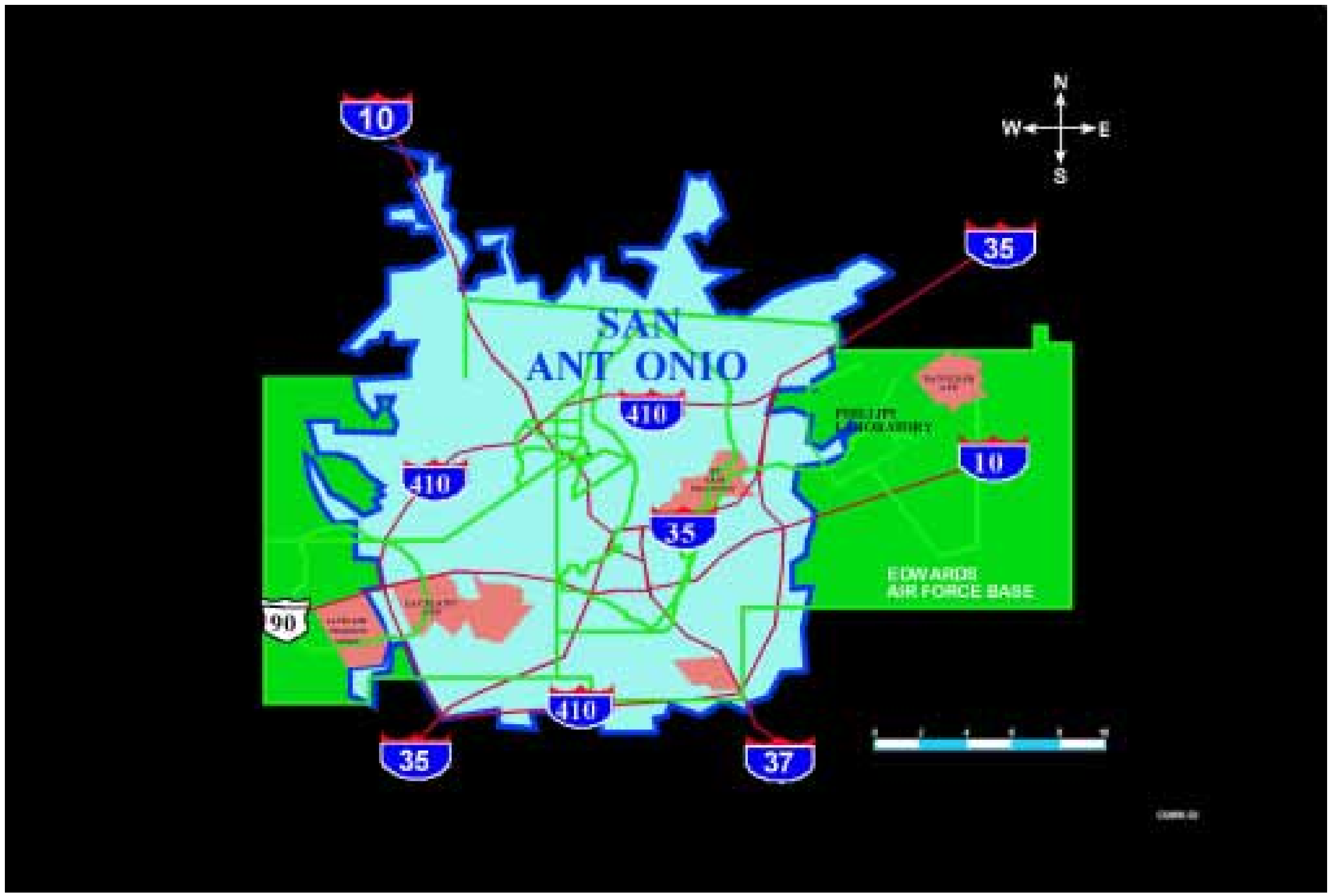


EDWARDS AFB

Relative Size



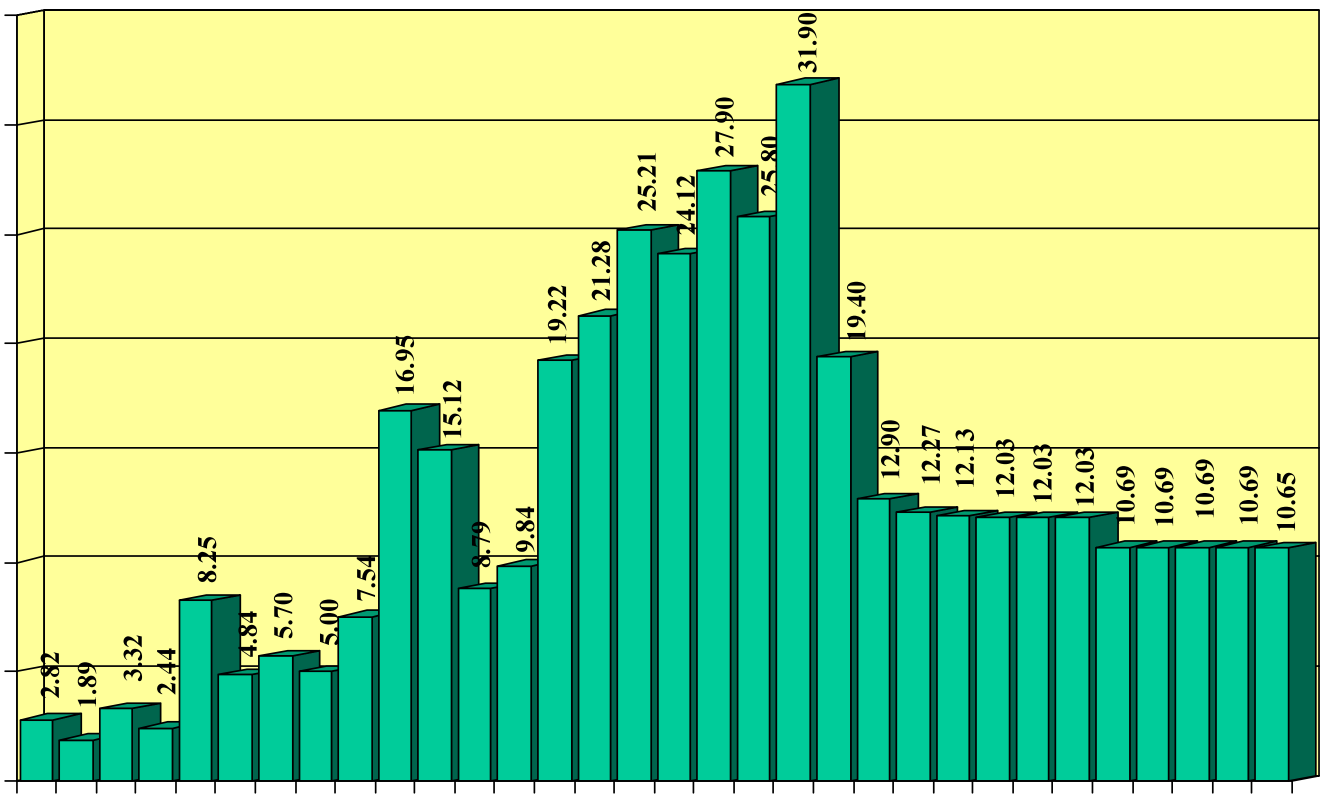
Edwards AFB Compared to San Antonio, Texas



Contaminants of Concern

- Jet fuel, Diesel, RP-1, Gasoline
- Solvents (TCE, PCE, TCA, Freon, Carbon Tetrachloride)
- Chemical Warfare Agents
- NDMA (N-Nitrosodimethyl Amine)
- MTBE (Methyl tertiary Butyl Ether)
- Perchlorate

Total Edwards AFB AF-ERA Funding by Fiscal Year



LTM/LTO Sampling and Analysis Costs

- Taking the sample
- Sample analysis
- Sample QA/QC
- LTM, LTO report preparation
- Loading sample results into GIS
- Changes to LTO and Land Use Controls
- Estimated to be 1/3 of the LTM/LTO budget

Stewardship & Technology: Challenges for Future Management of Radiologically Contaminated Sites

Tom Schneider

Ohio EPA

Office of Federal Facilities Oversight

Radionuclide Team

Facilitate the cleanup of radioactively-contaminated federal facilities by fostering dialogue between states, stakeholders and federal agencies in order to increase awareness of issues and procedures at sites in other states, encourage regulatory cooperation and share technological successes and approaches.

CO, OH, ID, NV, SC, TN, WA

"Stewardship & Technology: Challenges for Future Management of Radiologically Contaminated Sites"

- -Disposal Facilities
- -Groundwater
- -Institutional Controls
- -Data Retention

Stewardship Technology Challenges:

Disposal Facilities

- Cap Structures
- Monitoring
  - Vegetation
  - Water Balance
  - Subsidence
- Leachate
  - Collection
  - Treatment

Stewardship Technology Challenges:

Groundwater

- Gradient Control
- Monitoring
    - Elevations
    - Concentrations
    - Chemistry
- Institutional Controls

Stewardship Technology Challenges:

Institutional Controls

- Passive Controls
- Active Controls
- Redundancy
- Information/Data Retention
- Education

Stewardship Technology Challenges:

Information Retention

- Data Warehousing
    - Format
    - Media
- Remote Data Collection
- Local Availability
- Which Information to Keep?
- Education

USDOE Fernald
"Post Closure Stewardship Technology Project"

- **Collaborative Effort**
- **Technology Deployment**
- **Based at DOE Fernald Site**

Further Information

http://offo2.epa.state.oh.us/

www.itrcweb.org/

www.fernald.gov

Long Term Monitoring Sensor/Analytical Methods Workshop

Kathleen Yager

U.S. EPA

Technology Innovation Office

June 13, 2001

TIO Partners/Contacts

- Petroleum industry
- Chemical industry
- Manufacturing industry
- Pharmaceutical industry
- Local developers - Brownfields
- Army Corps of Engineers
- US Navy
- US Air Force
- US EPA and State Regulators

Sensor-Related Projects

- Development of SenTIX website – www.sentix.org
- Two review papers underway on available chemical and bioluminescent sensors
- Monitoring and Measurement for 21st Century (21M2) – cluin.org/programs/21m2
- Field demonstration of Burge TCE sensor with AFCEE

Industry/RP Receptiveness to Sensors

- Picture is confusing right now
- LTM has not been a high priority
- Industry is only now beginning to understand that many remedies will be long term
- Industry driven by "time-value of money" and anything beyond 20 yrs is "free"

Example Responses from Industry

- Not very interested “concerned about getting too much data (false positives) to report to regulators”
- “Not a high priority for us” – chemical and petroleum industry
- Sounds good “wish someone would develop these”
- Would consider if proven “reliable, durable, cost effective and acceptable to regulators”

"Packaging and Marketing may be the Key"

- Need to market sensors to fit the client's problem rather than just describe their attributes
- Sensor-specific information may be 2-3 layers down from perceived problem
- Sensors not likely to be a large investment area for industry, but if proven effective, will consider their use

VOCs/Semi VOCs
Groundwater/Soils/Vapor

30 Developers
10 Users
6 Technology Supporters

Monitors for Organics

<u>Requirements</u>

1. Threshold measurement (e.g., 5 ppb mcc)

2. Quantitative (± 20%)

3. Reliable (2 years including maintenance)

4. Appropriate dynamic range (based on problem)

5. In well (now), In ground (future)

6. Point measurement (most)/Flux (some – maybe)

7. Simple to operate, simple to understand (public)

8. Evolving need – Now process monitoring – LTM

9. Compounds of Interest
   CVOCs (TCE, PCE, CClu)
   Hydrocarbons
   Breakdown products/Toxicology
   Indicator species
   Cocontaminants (hydraulic fluids, lard oil, PCB's in oil)

10. Interferences (target 51%)

11. Frequency (< 3 months)

12. Ruggedness – True Grit

13. Cost (significantly less than current baseline)
    Comparison baseline
    $500 sample for 2 years
    $4000 upper limit

Summary Presentation for Metals in Soils and Ground Water

- Real-time not critical in Long Term Monitoring
- Focus on surface water not ground water (cost)
- Limit what is collected based on regulatory analysis
- Representation of sample is critical
- Don’t preclude solutions/system approvals
- Limit by representation

Soils

- Not part of LTM, but big long-term cost (remediation/land use transfer)
- Field deployable detectors
- One time use, not there forever
- Cone penetrometer as platform
- Large range of metals (Hg, Pb, Be)

Ground Water/Vadose Zone

Question need for in situ sensors

- Infrequent
- Calibrate/maintain/verification
- Cost of individual sensors
- Performance monitoring of containment structures (passive reactive barriers, etc.)
- Use of surrogates versus collection of metals info (pH, water levels, etc.)

Surface Water/Ground Water

- Frequency NPDES based/ mass based
- Sample on demand/storm events
- Dissolved/particulate (representative)
- Lab/Field analysis - cost
- Mercury, 10-50 ppt (total
- Chromium, Lead
- CERCLA is driven by risk, monitor species

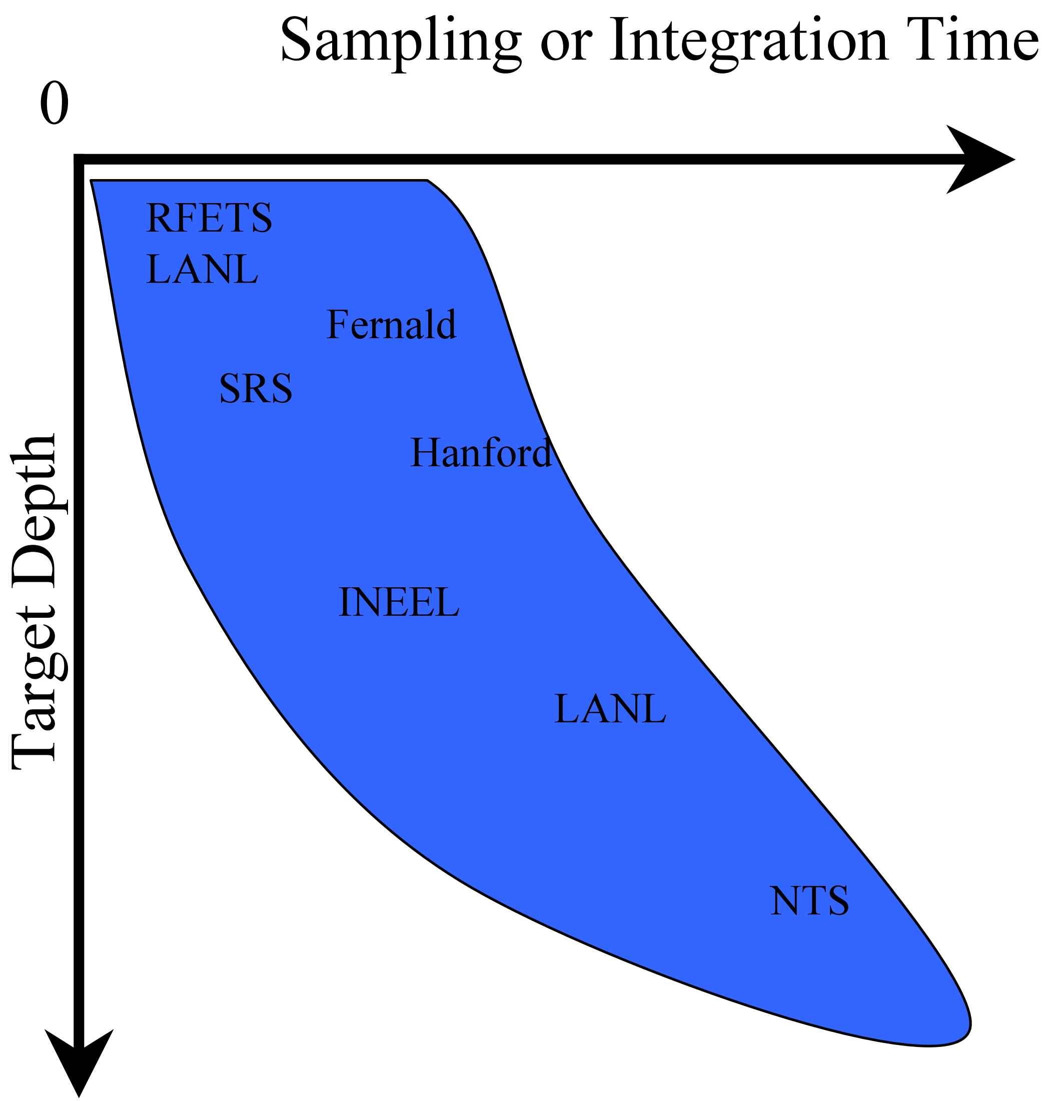
Future Considerations

- Species Specific/Precursors
- Biological Sentinels Supplement/Replace
  - Less expensive/ more representative
  - Stakeholder acceptance
- STCG Needs update/starting point
  - Purposefully generic
  - Things change
- Focus on what is really needed and what is cheapest for the long term

LTM - Radionuclides in Groundwater

- NTS
  - HTO & γ, <4000' 0'
- INEEL
  - U, Pu, Am, Sr, 0-500'
- Hanford
  - ^{99}Tc, HTO, U, ^{90}Sr, (I-129), 0-300'
- SRS
  - HTO, ^{90}Sr, 0-200'
- Fernald
  - U, 0-100'
- LANL
  - Pu, Am (colloids), U, 0', <2000'
- RFETS
  - Pu, Am (colloids), U surface water

LTM - Water Transport Scaling



LTM - Beyond Water

- Soils and Structure Monitoring
  - Surface soils
  - Phyto-remediation/extraction systems
  - Caps & Covers
  - Permeable Reactive Barriers
  - Liners & Impermeable Barriers
  - Concrete and residual infrastructure

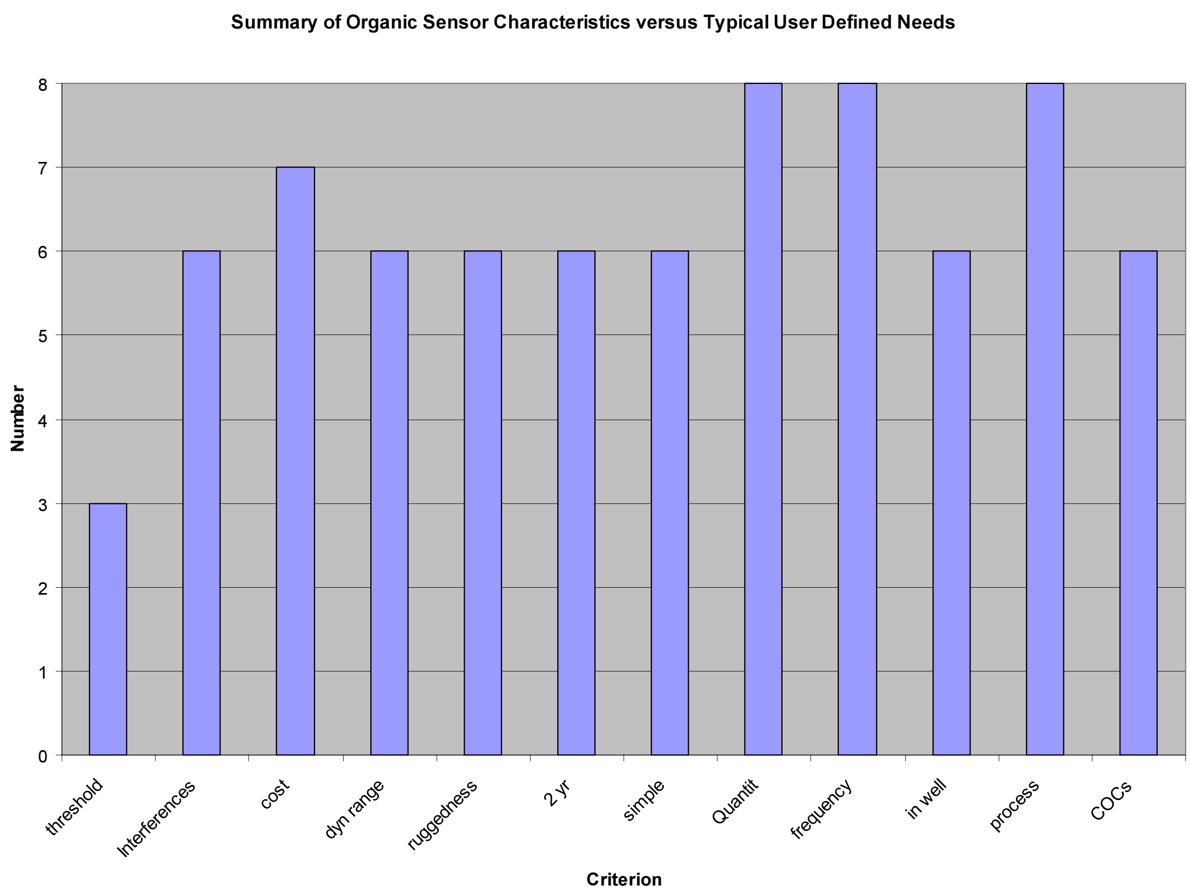
LTM - Drivers

- Risk management & evaluation
- CERCLA, RCRA
- Stakeholders
- Regulators & States
- Operating permits
- Response actions

LTM - Key Issues

- Decision Quality Objectives
  - connection to drivers and actions
- Sensor quality, stability and sensitivity
  - evolution and application strategy
- Integration
  - Radioactive contaminants
  - system parameters/processes (e.g. water flux)

Summary Graph From Gauntlet of Needs



Technologies

- Chemiresistor
- Planar waveguide w/coatings
- REMPI
- MIP Sensors
- Microbalance w/ coatings
- Heated probe, line, fast GCMS
- Permeable tube
- Burge TCE (Fujiwara)
- Immunosensor

Organic Sensor "Consensus"

- Though none of the sensors met all user criteria for needs, it appeared that most of the sensors could fill an identified application niche
- Many sensors met short term needs for process or performance monitoring
- Successful process and performance monitoring may be a stepping stone to long term monitoring needs.

Sensor Deployment "Consensus"

- Use of available-standard protocols within platforms is a key factor
  - 4-20 mA, 0-10 v, etc
  - IEEE, SAE, LIMS, ASTM ….
- Encouraging development of a few standard deployment platforms/approaches (open architecture) may foster development speed, technology acceptance, and collaboration leading to multiple sensors working together.
  - e.g., Burge, CPT based, etc.

Sensor Deployment "Consensus" (2)

- Installations based on "hanging" in a well may be influenced by heterogeneity and show more variability than pump based sampling
- Integration may be a way to deal with heterogeneity and reduce number of samples for long term (mass transfer limited sites).
  - Examples, permeable tube sampler, Burge, remote and other volumetric sensors
- Hybrid approaches may be better in the short term that include valve systems and calibration/blanking as part of platform.

Future Investment

- Invest in sensors in all stages of the technology development process. Bridge valley between basic research and deployment.
- Examine value of sensors over alternatives and develop and document the results. This might assist in more strategic decisions.
  - What do the true users (the family across the street) want?

Future Investment (2)

- Consider some near term investment in “low hanging fruit”
  - field sensors that are ready to go (Edwards AFB left with three new sensors to deploy from this meeting!)
  - Take advantage of existing sites (e.g. SRS, OR, Hanford, INEEL etc.) and piggyback on new sites such as the long term stewardship effort at Fernald
- Invest in “training” for regulators, site people and others to help them understand current data and set the stage for progress and innovation

Functional Requirements for LTM of Metals (1)

- Monitoring for Compliance (RCRA Metals)
- Monitoring Performance (e.g. Barrier Failure)
- Obtaining a Representative Sample is Essential
- Cost Effective Relative to Baseline Technology

Functional Requirements for LTM of Metals (2)

- Calibrated Measurements
- Accurate Detection of Metals to Meet Site Regulatory Requirements
- Sensitivity of Measurement Determined by Required Application
- Potential Interferences Must Be Known
- Compatible with Site Deployment Systems

Functional Requirements for LTM of Metals (3)

- Rugged and Reliable over Design Lifetime
- Minimize Waste

Available Technologies (1)

- **Note: No In Situ Long Term Monitoring Systems Currently Available**

- XRF
  - Field Screening and Field Transportable System Available
  - Multielement Capability
  - Best for Soil Using Standard Sampling Techniques

Available Technologies (2)

- LIBS
  - Works Best with Less Refractory Elements
  - Works Well for Be
  - Field Demonstrated for Characterization Activity
  - Not a Commercially Available Monitoring Tool
  - Unit Cost $80K-$100K

Available Technologies (3)

- ASV
  - OK for Field Screening
  - ppb Sensitivity in Water
  - Long Term Calibration Stability ?
- Colorimetric and Fluorescence Methods
  - Useful for Field Screening of Metals in Water
  - Relatively Inexpensive

Available Technologies (4)

- Immunoassay Screening Methods
  - Useful for Field Screening of Soil and Water
  - Useful for PCBs, Pesticides, and Metals
  - Detection Limits for Metals at ppb Level

General Research Strategies Recommendations

- Balanced Research Program(Basic and, Applied Research, and Deployment)
- More Support for Applied Research
- Keep Development Pipeline Full
- Extended Response Time to Call for Proposals
- Applied Research (EM-50 and SBIR Phase II) Calls for Proposal Should Consider Innovative Uses of Existing Technology

Future R&D Programs (1)

- Funding Mechanisms
  - Basic Research
    - EMSP
    - SBIR Phase 1
  - Applied Research
    - EM-50
    - SBIR Phase II
  - Field Deployment
    - Core/Quick Win
    - SBIR Phase III

Basic Level Research Objectives and Examples

- Minimize Waste Generation
- Lower Costs (Baseline Technology)
- Technologies to Access Difficult Locations

  – Metal Specific Membranes
  – MEMS
  – "Lab-on-Chip"
  – Disposable Systems

Applied Research Objectives and Examples

- Produce Field Prototype
- Partner Developer with Deployers
  - Microcantilever Detectors for Hg
  - LIBS for Hg and Other Metals
  - Surrogate Measurements (e.g. pH, Conductivity)
  - ASV
  - Moisture in Vadose Zone
  - Metal Optrodes

Quick Win/Core Objectives and Examples

- Deploy Technology within 2-3 Years of Project Inception
  - Water Level Change Monitors to Monitor Barrier Performance
  - Moisture Sensor for Barrier Performance
  - ASV Hg Sensor

Conclusions

- Real-Time Sensor/Monitoring Systems Should Be Considered When Increased Monitoring Frequency is Required (e.g. Surface Water Monitoring, Monitoring during Redemption, and Impoundment Monitoring)
- High Initial Capital Cost Can be Expected. However, as Sampling Frequency Increases Operational Cost (vs Sampling) Will Decrease

Conclusions

- More of a Need to Develop Sensors for Water Monitoring than Soil Monitoring

Long-term Monitoring Sensors/Analytical Methods Workshop

June 15, 2001

Summary of Radionuclides Group Discussions

Key Problem at DOE Sites

- LANL: water flux, Pu
- NTS: water flux, tritium
- BNL, LLNL: no user but cited tritium problems
- Fernald: U in groundwater
- Mound: tritium
- SRS: tritium
- INEEL: water flux, mobile rads vadose zone (not user)
- Hanford: Tc-99, lesser Sr, Am, Pu, U, Cs
- UMTRA: U in groundwater

Desirable Performance Goals

- Precision, reliability, accuracy, selectivity
- Easy to use, understand, calibrate, maintain
- Detection limit (0.1MCL)
- Integrating or qualitative sensors are also important
- Indicators of env. health, remed. control and effectiveness, engineered system performance, stabilization, etc.
- To regulatory levels or other drivers
- Automated, remote telemetry, field, possibly in situ
- Lower overall cost compared to baseline ($1K-50K)

Potential Quick Wins Available Immediately

- Tritium, at-well FDTAS
  (field deployable tritium analysis system)
- Field-deployable Tc-99 monitor
  - 3M sampling disk with autosampler
  - EMSP separation membrane with scintillator
- Integrated Water Movement Monitoring System (water content, tension, flux)
  - Available now
  - Recommend autosampler at some points in system
  - Water flux as surrogate for transport/measure rad

lower priority: lower energy gamma ray detectors for downhole (HgI2, CZT, Xe)

2-5 Year Research Needs

- Field-scale modeling verification (flow and transport)
- Integrated, multi-monitor, water flux/contaminant monitoring system (correct sampling rates, triggers)
- Development of mobile, non (or low energy) rads
  (Sr, H-3, Tc, Am, Pu)
- Measure over time the degradation rates of engineered systems assumes in P.A.s
- Need at many sites for improved (automated?) samplers for vadose, groundwater, and surface water
- Research, technology for assuring vertical isolation
- Delivery of LTM systems into subsurface
- Sampling for episodic events

Concluding Remarks

- Understanding of entire site system, transport processes, risk will lead to strategies on where to put wells and monitors, what to monitor, how to install, and how to understand results from monitor system
- Few commercial *in situ* radiation monitors (1 CPT string)
- Very few field-deployable β and α monitors and only 1 downhole - FTDAS for tritium (needs another look)

APPENDIX O: Analysis of Needs Statements

Analysis of Needs Statements - 207 Total Needs
(Duplications eliminated)

Contaminants of Concern (as given in Need Statement)	# of requests for COC	Stage of Development of Need Requested	# of requests
Metals	4	Applied Technologies	123
Cr+6	6	Basic Technologies	62
Hg	5	Basic and Applied	9
Pb	2	NA or other	13
Co	1		
As	1		
Na	1		
Ba	2		
Se	1		
Sr-90	8		
Cs-137	2		
Pu	8		
Th	1		
Am	2		
U	6		
I-129	3		
Tc-99	6		
Ra-226	1		
Tritium	8		
Radon	1		
Radionuclides	16		
alpha emitters	1		
beta emitters	1		
gamma emitters	1		
actinides	1		
SNF	1		
Organics	2		
VOCs	8		
chlorinated solvents	3		
DNAPL	3		
LNAPL	1		
NAPL	1		
TCE	3		
PCE	2		
CCl4	2		
PCB	3		
Inorganics	1		
Nitrate	2		
TRU	3		
Hazardous/Toxic	3		
HE (RDX and HMX)	3		
Pyrophoric	1		
Buried Waste	4		
TATB and DMF	1		

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The ability to quantify the presence of radionuclides in the environment is a critical DOE need. Among the categories of needs assembled for the workshop (radionuclides, metals, and organics), radionuclides had the largest number of needs statements. Furthermore, radionuclide contamination is largely a DOE-owned problem. Key radionuclides of concern include tritium, U, Tc, Sr-90, Pu and Am. The greatest concern is radionuclides that are mobile in the environment and cannot be practically detected and identified using gamma spectroscopy.

There are many reasons to consider the use of sensors for on-site or in-situ monitoring of radionuclides. However, few such sensors exist, particularly for those radionuclides normally detected from their alpha or beta emissions. In general, most available detectors are simply radioactivity detectors. Sensors for surface waters, ground waters, or vadose zone that are selective for specific radionuclides, particularly the alpha and beta-emitters, are not available.

Thus, development of radionuclide sensors is a critical DOE need and it is unambiguously a DOE responsibility.

Some of the sensing methods currently under development include selective scintillating microspheres, spectroelectrochemical sensors, and stripping voltammetry sensors. Chemical sensing methods may be applicable to those radionuclides where the required detection limits are not too stringent, such as uranium. For radionuclides where the required detection limits are far beyond the capabilities of any known or conceivable chemical sensing method, radioactivity detection is necessary. Radioactivity detection is also required when radioactive isotopes of concern must be distinguished from stable natural isotopes. For detection on the basis of alpha or beta emissions, some method of separating the radionuclide of interest from interfering species and localization in the detection volume of a detector must be incorporated into the sensing mechanism.

The functional requirements for radionuclide sensors to be sensitive, selective, etc are similar to those of other sensors and will not be reiterated here. It should be emphasized, however, that radionuclide sensing involves requirements for ultra-trace level detection, based on standards such as maximum contaminant levels or drinking water standards and the 4 mrem/yr Effective Dose Equivalent. The incredibly low detection limits required for most radionuclide contaminants is a distinguishing feature of radionuclide sensing.

Dr. John Plodinec
Director, DIAL at MSU

A STRATEGY FOR ASSURED DEVELOPMENT OF LONG-TERM MONITORING CAPABILITIES

Over the past decade, the Department of Energy has taken its initial steps on the long journey toward eliminating the environmental legacy of the Cold War. In the coming century, DOE will complete remediation of nearly all of its sites. As a result, DOE will shift much of its environmental focus from management of active waste sites to monitoring of closed sites and facilities across the country.

This shift in focus is a huge undertaking. Management of waste is an active process, based on the assumption that contamination from the waste is likely to occur if action is not taken. The goal of waste management is essentially to maintain the waste in a stable condition. Conversely, monitoring is a passive activity: its focus is information, not action. The goal of monitoring is to detect a change in the condition of the waste - indicating movement - based on the assumption that the condition of the waste should not change, i.e., movement of contamination should not occur.

This shift from management to monitoring will require DOE facility managers to change the emphasis, type and allocation of resources at each site. Effective direction and management of the long-term monitoring component of the Stewardship program is essential to avoid unnecessary expenditure while ensuring program effectiveness. Key components which must be addressed are:

- Personnel costs. Roughly three-fourths of DOE's waste management bill is for people. If savings are to be realized by closing sites, then monitoring must be done with a minimum of human involvement. This begins to provide functional performance requirements (FPRs) for sensors for long-term monitoring (LTM): no manual sample preparation required, long mean times between failures, and automated status indicators to signal when maintenance is required.

- Public involvement. Experience at sites such as Hanford and Fernald indicate that, without public confidence, delays are inevitable, which drive up the total cost. While the public is unlikely to understand technical nuances, they will certainly expect assurance that no harm will befall them from a closed site. This translates into an FPR that sensors must be able to provide timely warning of a change in condition of a given site. Further, if an indirect indicator is used (e.g., moisture detection as an indicator of waste migration), there must be a clear case establishing that the indicator in fact is indicative of the change in condition of the waste.

(Plodinec, cont.)

- "Long-term" means long-term. Significant hazards may exist on a given site for decades if not centuries. Over that time frame, better solutions almost inevitably will evolve, particularly for monitoring. Obsolescence must be planned for. All too often, DOE's waste management program has not been able to take advantage of new technology, because removal of the old is prohibitively expensive. In the case of long-term monitoring, new technologies in the area of long-lived batteries, telemetry, sensors, nanotechnology and remote sensing are likely to revolutionize site monitoring over the next quarter century. The monitoring component of the Stewardship program must be set up so that DOE can take advantage of advances such as these. A key part of this is that sensors must conform to well-established standards whenever these are available. Further, it is imperative that DOE's Stewardship program establishes and maintains contact with key standards organizations so that when standards (e.g., for data communication) change, DOE can try to minimize impacts of the changes.

- Adequacy of resources. Every major DOE waste management project has suffered because of underfunding of the analytical function. In the case of the DWPF, for example, the throughput of the facility is limited by the capacity of the analytical laboratory. In the case of the long-term Stewardship program, there is a danger that inadequate emphasis on the role of analysis and monitoring could undermine public confidence, thus driving up total costs.

Albert Robbat
Tufts University

There was very little discussion about alternative technologies or approaches from sensors. For example, a series of Geoprobe or cone penetrometer soil or water vapor extraction probes multiplexed in, and around a contaminated plume, tied directly to an on-line mass spectrometer can provide real-time monitoring of multiple contaminants. This would allow real-time insight into the progress of bioremediation, e.g., monitor the decrease and concomitant increase of parent and degradation products, respectively, as well as serve as an alarm system to insure that contaminants are not moving (e.g., containment is working). The latter was stressed repeatedly by site managers during the workshop.

Research into collection technologies, system integration, data reduction, and demonstration is needed. To make this work, MS deconvolution techniques are needed to deconvolve spectral interferences to eliminate the need for GC separation prior to MS analysis.

StephenFarrington
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The overall objective is to reduce cost. Whatever is developed should have the broadest applicability and demonstrated value for the least cost, both to prove the viability of a sensing-based approach to LTM and to set the stage for user and regulatory acceptance of future developments.

There are essentially two purposes for long-term monitoring. Each has different sensing requirements. The first purpose is regulatory compliance; demonstrating that "the plume did not leave the room." For this requirement, systems that can report concentrations of COCs at or near MCLs or other regulatory limits are required. The second purpose of LTM is change detection; providing early detection and warning of when a model, a structure, or a process has failed (i.e., that the conditions assumed in a ROD have changed). These two purposes impose separate functional requirements. However, it all boil down to cost and data defensibility. LTM for change detection least constrains R&D of an acceptable solution because it least constrains the definition of defensibility. Change detection, in contrast to compliance monitoring, is not constrained to using the concentration of a COC as the solely acceptable metric for supporting a management decision.

Systems that can measure *surrogates* or *indicators*, such as pH, ORP, conductivity, temperature, DO, water level, soil moisture, matric potential, and/or electrical conductivity, and which can discern real changes from noise (i.e., anti-alias the signal) are the most sensible to develop first. The return on initial investments is likely to be greatest in change detection, rather than COC monitoring for regulatory compliance, since much of the technology required has already been developed.

Many excellent sensors for both *indicators* and COCs already exist. The real challenge is not sensor development; it is *in situ* field instrumentation. The process of making an environmental measurement requires several stages (e.g., sample collection, sample introduction, transduction, amplification, signal conditioning, digitization, etc.). The sensor is responsible only for transduction, a small and relatively inexpensive piece of the picture. A development effort should focus be on the stages that precede transduction. Sample collection and introduction alone are challenging enough to require a concerted development effort. In them lie the requirements for sample representativeness, sensor deployment mechanism, and system longevity. This is a problem that we, as an industry, have a strong capability to solve now, with the highest return on investment. It is a development whose success can be easily demonstrated using COTS products as the sensing elements for indicators or surrogates. In addition, solving this piece of the problem, while focusing on change detection monitoring, rather than a specific COC, in a specific mixture, within a specific medium, has the widest applicability across the DOE complex.

Sensing-based approaches can provide a significant cost reduction in the area of data management because the numerical value representing a measurement can be transferred automatically into a database, decision support tool, report generator, or computer model. This both reduces the manpower associated with manual data entry and eliminates transcription errors. Cost-benefit analyses should consider these benefits, and not simply set the value of a sensing system at the cost of obtaining a measurement using baseline technology.

(Farrington, cont.)

An additional benefit of sensing-based approaches is the ability to anti-alias the data produced. Aliasing is a significant problem with current practice in LTM. In most circumstances, it takes many years of quarterly sampling data to discern a temporal trend in *in situ* contaminant concentrations, because discrete measurements are taken at a lower frequency than that of naturally superimposed fluctuations. A key benefit of sensors-based LTM is the ability to easily *anti-alias* (i.e., to discern real change from noise). There are only two ways to accomplish this; averaging and low-pass filtering. Each can be performed either physically (in the course of taking the measurement), or by data processing. *In situ* sensing allows both. Physical *averaging* may be accomplished by using integrating sensors. For example, rather than develop an ultra sensitive beta detector, emissions from tritium in a monitoring well can be counted over an entire quarterly monitoring period while also monitoring flow through the well. Dividing the count by the volumetric flux will yield a quarterly average concentration. Physical *low-pass filtering* may be accomplished by using inherently slower-responding systems. For example, the INEEL advanced tensiometer's response rate is slower than natural diurnal fluctuations in soil water potential. Averaging and low-pass filtering may be performed numerically if the measurement data are frequent enough. Both the physical and numerical approaches have their advantages and disadvantages. Regardless, though, sensing rather than sampling offers the most cost-effective ability to anti-alias.

In summary, the greatest development need is for instruments that can obtain a representative sample from the environment while providing adequate protection for a variety of sensing elements that already exist. It would be pragmatic to first demonstrate the success of this approach in a change detection monitoring mode, rather than for regulatory compliance monitoring. Using existing COTS sensors for pressure and water level, pH, ORP, conductivity, DO, and temperature in groundwater, and/or soil matric potential, moisture content, resistivity, and temperature in the vadose zone, one would demonstrate the ability to package, deploy, and protect sensors in a way that produces a representative sample before embarking on the development of new sensors designed to meet the sensitivity, accuracy, specificity, and repeatability demands of defensible regulatory compliance data. Additionally, some attention should be afforded the data handling that occurs once a measurement has been obtained, so that the cost savings afforded by having that number automatically available, electronically, from a sensor can also be realized.

References

The citations for all references in this report have been fully described where noted in the text. Two general references for major Long-Term Stewardship documents are provided below:

Report to Congress: FY2000 National Defense Authorization Act, Long-Term Stewardship Report, January 19, 2001

Available online: <http://lts.apps.em.doe.gov/center/ndaareport.html>

Bridging the Gap between Closure and Long-Term Stewardship - Ensuring a Smooth Transition, February 27, 2001

Available online: <http://lts.apps.em.doe.gov/center/reports/pdf/doc208.pdf>

APPENDIX R: Acronyms

Acronyms:

Am	Americium
ARA	Applied Research Associates
ARAR	Applicable or relevant and appropriate requirements
ASTD	Accelerated Site Technology Deployment
ASV	Anodic stripping voltammetry
CERCLA	The Comprehensive Environmental Response, Compensation, and Liability Act
CMST	Characterization, Monitoring, and Sensor Technology Crosscutting Program
COC	contaminants of concern
Cs	cesium
DOE	Department of Energy
DQO	Decision Quality Objective or Data Quality Objective
EM-22	Dept. of Energy, Office of Environmental Management
EM-50	Dept. of Energy, Office of Environmental Management, Office of Science and Technology
EMSP	Environmental Management Science Program
EPA	Environmental Protection Agency
FDTAS	Field Detection Tritium Analysis System
FFCA	Federal Facilities Compliance Act
FIU	Florida International University
GW	ground water
HTO	Tritium in water, Hydrogen Tritium Oxygen
ITSR	Innovative Technology Summary Report
LIBS	Laser-Induced Breakdown Spectroscopy
LTM	long-term monitoring
MCLs	maximum concentration levels
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OST	Dept. of Energy, Office of Environmental Management, Office of Science and Technology
PARC	precision, reliability, accuracy, comparability
PNNL	Pacific Northwest National Laboratory
ppb	parts per billion
ppm	parts per million
pCi	pico Curies
Pu	plutonium
RAM	Reliability, availability, maintainability
RCRA	The Resource Conservation and Recovery Act of 1976
R&D	Research and development
RPM	Remedial Project Manager
SCFA	Subsurface Contaminant Focus Area
SEA	Science and Engineering Associates
Sr	strontium

SRTC	Savannah River Technology Center
STCG	Site Technology Coordination Group
Tc	technetium
TMS	Technology Management System
TPA	Tri-Party Agreement
UMPTRA	Uranium Mine Tailings
VOC	volatile organic compounds
XRF	x-ray fluorescence